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NASA SPACE PROGRAM

HEARINGS

BEFORE

SUBCOMMITTEES OF THE

COMMITTEE ON APPROPRIATIONS
UNITED STATES SENATE

NINETY-NINTH CONGRESS

SECOND SESSION

SPECIAL HEARINGS (March 25-26, 1986)

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT
DEPARTMENT OF DEFENSE, Afternoon, March 26, 1986

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SPACE PROGRAM

TUESDAY, MARCH 25, 1986

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 10 a.m. in room SD–123, Dirksen Senate Office Building, Hon. Jake Garn (chairman) presiding.

Present: Senators Garn, D'Amato, and Lautenberg.

INDUSTRIAL UTILIZATION OF SPACE TECHNOLOGY

OPENING REMARKS

Senator GARN. The subcommittee will come to order.

There has been a great deal of discussion in recent weeks, in the wake of the tragic loss of Challenger and her seven-member crew, about NASA and the future of America's space programs. There has also been a great deal said about the accident itself, both in speculation about its cause and questions about who or what can be blamed for the terrible tragedy.

These hearings will not attempt to address the question of cause or responsibility; those issues are still being examined by the Presidential Commission, and we will await the report of the Commission's findings before we can appropriately review these matters in Congress.

These hearings and others yet to be scheduled will begin to address the question of the future of our space program. They will begin doing so by setting our discussions in the broader perspective of the value of our Nation's space programs. This will include the contributions that have already been made by NASA in its technological development activities over the past 25 years, and some of the less tangible but, undeniably, unique and significant benefits for this Nation and, in fact, all of mankind's efforts to search in the heavens for a better understanding of our world and our origins.

FOCUS OF MORNING SESSION

The focus of this morning's session is from a very distinguished group of individuals whose perspective not only reflects a deep interest in astronautics, but also the very open and active private sector involvement in our Nation's space program.

We are not only honored to hear from a man who has personally wrestled with a satellite in space and won, but also another whose experience in orbit exceeds all other Americans' and yet another whose ability to get into space eclipses that of a mere politician.

The three gentlemen I speak of are, of course, Joe Allen, Pete Conrad, and my fellow crew member on STS 51–D, Charlie Walker.

In addition, we have Mr. Robert Hood and Dr. Karl Harr with us this morning who, from their perspectives, will elaborate on the perspective of our private sector industrial base.

On behalf of the subcommittee, I am pleased to welcome all of you to the committee. I should also note that through the kindness of the International Association of Firefighters, NASA, and Leviton, we have exhibits in the back of this hearing room which I encourage the audience to view following the conclusion of this session, if they have not already done so.

I would also like, on behalf of the subcommittee, to thank all our witnesses for interrupting their very busy schedules to accommodate us.

I fear that as we in the Congress are confronted with the pressures of addressing not only severe budgetary constraints, but also the complexity of program and policy decisions. We may find that our grasp of these issues exceeds our understanding. Your willingness and the generous cooperation and understanding of your colleagues who will appear later today and tomorrow in accommodating our limited schedule to meet our need far more than halfway is certainly appreciated.

I only hope that as we wend our way during this difficult period that at some later point we will have the opportunity to delve further into all the aspects of space technology benefits, including matters such as heart pacemaker improvements, insulin pumps and the whole panoply of technological developments that are finding terrestrial applications.

Gentlemen, again, we are happy to have all of you with us.

Dr. Allen, if you would like to begin?

SPACE INDUSTRIES, INC.

STATEMENT OF DR. JOSEPH P. ALLEN, EXECUTIVE VICE PRESIDENT

Mr. ALLEN. Thank you, Mr. Chairman.

I am very pleased to have been asked to appear before you this morning. I am an employee of a small but bold space company, Space Industries, Inc., in Houston, TX, and I have been with the company for just about 6 months. However, I have been associated with the space business for nearly 20 years and I speak this morning with that background.

As you personally know, space is very close at hand. It is just about 8 minutes and 80 miles away. Earth itself is as much a part of space as meteors, Halley's Comet, and the Sun, an integral part of space.

Yet, without the aid of rockets that can hurl us beyond our planet's hold, we can only dimly peer beyond the atmosphere; and we can't venture away from home, exactly as those persons 1,000 years ago without ships could only stand on the shore and look out to the ocean.

The rocket that we are now using as the national space transportation system, the shuttle has been in the news every day for nearly 2 months now because of the focus of attention over the tragic loss of the mighty Challenger. For that reason, it is particularly appropriate to have a hearing like this one that will give us a chance to step back and look with a longer perspective than just 2 months over that short history of the space program that we have all experienced in our lifetime.

EXTRAORDINARY ACHIEVEMENTS SPAN ONLY TWO DECADES

In the concern of the moment, it is all too easy to forget that our challenges and our accomplishments in space span only two decades, and are, by any measure, extraordinary, indeed. As we look back over that time, it is difficult now to realize that 25 years ago, we absolutely didn't know whether we could build a ship to survive the fiery entry into space and then the reentry back to planet Earth, and it is remarkable to realize that there are at least four people in this room that have done exactly that easily. And several here have done it several times, and I haven't even turned around to look behind me yet.

Twenty-five years ago we didn't know whether people could even survive in space, whether physically, the human body could survive, or mentally, the human psychology could tolerate the separation from Mother Earth. The possibility of landing people on the Moon 25 years ago was remote, and the idea of sending spaceships to Mars and beyond was just a distant dream. But it turned out they were not just dreams.

In this short period of time, American astronauts, including one at this table, have walked on the Moon; and during this time, our robot spacecraft have flown out to, flown around, flung past, landed on, or are on their way to every planet, except for one, in our solar system and returned thousands of pictures and millions and billions of bits of data that reveal the extraordinary nature of the planets, their moons and their outstanding ring systems.

Just within 5 years, we have begun to use our spacecraft more than one time; we land them like airplanes, as you very well know. We in the space community, both private sector and Government, are now planning for the construction of small, industrial facilities in space around even a more ambitious large, permanent outpost, a habitat, a station in space. All of this has been accomplished in less time than half the life span of an average American.

FOCUS SHIFTED TO OPERATION

As you also know, we are shifting the focus of space flight from exploration to operation. We are moving from an era of space travel, where astronauts were explorers, to the era of space utilization. You know from personal experience that astronauts who travel in space today are men and women who go there to work. They are scientists, pilots, technicians, and yes, Senators and Representatives who travel to space because of our growing knowledge of space and familiarity with space. We are workers who are increasingly at home in this new frontier.

Of course, any type of travel is a form of exploration, and it informs us about the new and unknown and offers us a fresh perspective and, most importantly, a new perspective of the place from which we travel. This is, indeed, the case with space travel.

Our quarter century of journeying into space beyond the edge of the Earth, has awakened in us the fact that we inhabit a very fragile and finite planet.

President Kennedy said 25 years ago that, "Space is the new ocean, and this Nation must sail upon it." Space today remains that ocean that beckons us outward, and like all oceans in our history, inevitably, it has turned our vision back toward our home, in this case, our small and beautiful planet.

HISTORY OF EXPLORATION

I arrived back in this country, Mr. Chairman, just 2 days ago from extended travel including some time that was spent in Genoa and in Milan, Italy, and I can assure you that one cannot travel to this part of the world, see newspaper accounts of the investigation of the loss of Challenger, answer questions asked by interested Italians, including, like here, very insistent Italian journalists, without thinking back upon that time nearly 500 years ago when journeys were being undertaken in ships from those European shores. Very little was known then about our Earth, including even the fact that it was a planet. You will remember that it was not known to those explorers that they would not sail right out to the edge of the Earth and fall from it. Yet brave men and women in those years set out upon those distant oceans, and a result of that exploration was to uncover the tremendous treasures of the beautiful planet on which we live.

Because of their discoveries, those nations that followed and plied the transportation routes then chartered reaped enormous economic, as well as intellectual, rewards. All of us involved in the space community, and particularly those involved in positions of leadership of this Nation, should be acutely aware of the lessons that the history of this time hundreds of years ago, should be teaching us.

NEW SPACE ROUTES CHARTED

That is precisely the message that I want to bring before the committee this morning. We have, in the last 20 years, charted new routes in space. Let us not now, of all times, lose our national resolve and as result, lose out on the economic and intellectual rewards to be found there.

Thinking back on the connection with Italy, the shuttle is a ship, by the way, which literally does travel out to the edge of the Earth and, in a sense, falls off the edge and continues to fall as it travels around the Earth.

A short time ago, I collaborated with a friend, Russell Martin, in writing some of my thoughts following my first trip to space aboard a space shuttle. I would like to conclude by paraphrasing the final paragraph of that text that we wrote:

> The fundamental reason for entering space is rooted in the nature of our species. We are the inquiring species, the creatures whose survival depend on knowledge and its use. The entire course of the space program has allowed us to become less theoretical about the nature of the Earth, its neighboring planets, and the emptiness that surrounds us all. Space is still a mysterious frontier, but because we have been there, we know far more than we could ever have known had we chosen not to go.

And we must continue this journeying outward. This is my conviction. It is the conviction of many in this room, and I can assure you from personal experience, Mr. Chairman, it is also the conviction of the families of the Challenger seven. When I leave here today, we will go back and get right to the business of a celebration which takes place on Thursday of this week in Houston on behalf of the Challenger; it is called "The Challenger Celebration: The Show Must Go On."

Thank you very much.

Senator GARN. Thank you very much, Joe.

[The statement and questions and answers follow:]

STATEMENT OF DR. JOSEPH P. ALLEN, EXECUTIVE VICE PRESIDENT, SPACE INDUSTRIES, INC.

Mr. Chairman:

I am very pleased to have been asked to appear before the subcommittee this morning. I am an employee of a small design company, Space Industries, Inc., located in Houston, Texas and I appear on behalf of that company where I have worked for about one-half year. However, I have been associated with the space business for nearly 20 years. As you know, space is incredibly close at hand. From any point on the earth, space is only about eighty miles away. The earth itself is as much a part of space as is the moon, or meteors, or the Milky Way, yet without the aid of rockets that can hurl us away from our planet's hold, we can only dimly peer beyond the atmosphere; we cannot venture away from home.

The rocket we now use as the national space transportation system, the Shuttle, has been in the news everyday for nearly two months now because of the worldwide focus of attention on the Challenger tragedy. For that reason it is particularly appropriate to step back and look with a longer perspective than just two-months' time.at what the short history of the space program itself perhaps means. In the concern and the furor of the moment it is very easy to forget that our challenges and our accomplishments in space span little more than two decades.

In looking back over this time, it is even difficult to recall that twenty-five years ago we did not know whether we could construct a spacecraft which could survive the fiery friction of reentry into the atmosphere, nor did we know for certain whether humans could endure the physical effects of weightlessness or for that matter the psychological effects of literal separation from the earth. Twenty-five years ago the possibilities of landing astronauts on the moon and returning them safely to earth, or sending spaceships to Mars to land on this red planet and dig in its soil for signs of life seemed like distant and naive dreams. But they were not. In this short period of time American astronauts have walked on the surface of the moon. Astronauts have lived in space for months at a time. Equally remarkable, within this period our robot spacecraft have flung past, circled around or landed upon or on their way to every planet in our solar system, save one, and have returned to us here on earth wonderful photographs and billions of bits of scientific information about these planets, their moons and their extraordinary ring systems. Just within the past five years have we begun to reuse our spaceships, launching them like rockets and returning them to earth like airplanes. And we, the space community, are now in the planning stages of constructing small manufacturing facilities and even a large permanent outpost in space—all of this we accomplished in less time than the life span of the average American citizen.

We have already begun to shift the focus of space flight from exploration to operation. We are moving from the inaugural era of space travel where astronauts were explorers and pioneers, to the operational era of space utilization, and you know from personal experience, Mr. Chairman, that the astronauts who travel to space today are men and women who go to space to work. They are scientists, pilots, technicians and, yes, senators and representatives who reflect our our growing knowledge of and familiarity of space. We are workers who are increasingly at home in this new frontier. Of course, any type of travel is a form of exploration--one that informs us about the new and unknown and offers us a fresh perspective and new understanding of the place from which we started. And this indeed is the case with space travel; our quarter century of journeying beyond the edge of the earth has awakened us to the fact that we inhabit a fragile and finite planet.

Before people of this planet had seen pictures of our planet taken from earth orbit or the startling photographs of it, small and blue, rising above the moon's gray horizon, it was difficult to grasp in an emotional way the truth that our home is just a sphere, a planet that orbits a rather ordinary star located in the corner of a minor galaxy. This truth is today very easy to accept because of our ventures into space and our perceptions of the fragile earth have been expanded enormously. Thus we have increased many fold our knowledge of the planet that is our home, the solar system of which we surely are an important part and of the universe of which we are but a tiny party. "Space is the new ocean," President Kennedy said when the Mercury program got underway 25 years ago, "and this nation must sail upon it." Space today remains that ocean that beckons us outward, but it inevitably has turned our vision back toward our small planet.

I arrived back in this country only two days ago from an extended journey, including some time spent around Genoa and Milan in Italy. One cannot travel to this part of the world, see newspaper accounts of the investigation of the Challenger tragedy, talk to people and answer questions asked by interested Italians and insistent Italian press without thinking back upon that time 500 years ago when journeys, like the journeys of the space Shuttle, were being undertaken in ships from these same European shores. Very little was known then about the planet earth, including even the fact that it was a planet. It was clear that great dangers lay ahead; it was by no means certain that the explorers of that time would not sail right to the edge of the earth and fall from it. Yet brave men and women in those years set out upon distant oceans. And a result of that exploration was to solve many of the mysteries of the beautiful planet on which we live. Most importantly, those nations that plied the transportation routes then charted reaped enormous economic and intellectual rewards. I genuinely feel that all of us involved in the space community, particularly those involved in positions of leadership of this nation should be acutely aware of lessons that the history of this time 500 years ago should be teaching us. We have charted these routes to space. Let us not lose our national resolve and, as a result, lose out on the economic and intellectual rewards to be found there.

Mr. Chairman, a short time ago I collaborated with a friend, Russell Martin, in writing out some of my thoughts following a journey in the space Shuttle which, through the marvel of human engineering, literally does fall around the edge of the earth. Let me conclude by paraphrasing the final paragraph of that text. "The fundamental reasons for entering space are rooted in the nature of our species. We are the inquiring species, the creatures whose survival depends on knowledge and its use. The promise of space is the promise of tangible solutions to environmental and resource problems, of improved communication among the peoples of the earth, of new technologies that hold the potential to help us lead more productive lives. The entire course of the space program has allowed us to become less theoretical about the nature of the earth, its neighboring planets, and the emptiness that surrounds us all. Space is still a mysterious frontier, but because we have been there, because we have begun to enter space, we know far more than we could have ever known had we chosen not to go. Space will forever lure us outward because it is a realm without boundaries, without limitations, without an end to the promise of understanding."

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE D'AMATO

SHUTTLE INVESTIGATION

Question: The Washington Post (Monday, March 24, 1986, Page A4) reported "Shuttle Inquiry Criticized by Industry Engineers -- Fear Voiced Probe is Becoming a 'Witch Hunt'." What is the position of the industries represented today concerning the status of the shuttle investigation:

Answer: I cannot speak for industries in general regarding their collective opinion of the ongoing shuttle investigation, but I will say as an individual that surely all corrective action taken upon conclusion of the investigation will be based on the final statements, not the interim statements, of the investigative commission. For that reason, to pass judgement, good or bad, on the official ongoing shuttle inquiry at this time is surely premature.

ELVs

Question: The industries represented today might want to elaborate on the status of the private sector involvement in the space program and the recommendations they might have for the future of this program. In particular, is there a need for further development of the Expendable Launch Vehicles (ELVs), as well as the space shuttle program? Or is it better to focus more attention on one, rather than both?

Answer: Since the business of Space Industries, Inc. is in the utilization of the space environment, not in the transportation to and from space I cannot comment with expertise on the proper balance of shuttle versus ELV or on government-provided transportation versus private-provided transportation except to say that the cheaper the better. Our business is out on that frontier. As the costs to travel there decrease, our business possibilities increase.

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INTRODUCTION OF SENATOR D'AMATO

Senator GARN. Mr. Hood, before I turn to you, I would like to turn to Senator D'Amato to see if he has any comments he wishes to make.

Senator D'AMATO. Thank you, Mr. Chairman.

First of all, let me tell you I am pleased to join you at these hearings and commend you, particularly as this focuses in on the industry perspective of the Space Shuttle Program, what our commitment should be with industry and the Federal Government and where the industry sees us going.

Mr. Chairman, in the interest of time, I have three questions that go into that area in terms of industry, where they see their role, and what we should be undertaking. I would like to submit them for the record

Senator GARN. I certainly would be happy to do that.

Senator D'AMATO. Thank you, Mr. Chairman.

INTRODUCTION OF SENATOR LAUTENBERG

Senator GARN. Senator Lautenberg, do you have any opening statement?

Senator LAUTENBERG. Just very briefly, Mr. Chairman.

I commend you for this review. I am pleased to have people from the industrial side of our space sector here with us, with all the talk about commercialization of space. I think you would agree that the communications satellite industry is really the largest private space industry.

I come from the industrial segment in our society, the computer business, in which we had a fairly significant interest in communications, and certainly, we could see directly the benefits of the activities that have taken place.

We are gathered here, I think, as our first witness suggested, to focus principally on the events of very recent months and the tragedy which moved us all, and as we review the opportunities and those investments that we should continue to make, we still need to know what happened with the *Challenger*. That doesn't suggest that we stop, but it certainly does say that we have to know what happened and why it happened. We need to correct the problem, but the accident does force us to take stock, Mr. Chairman.

NEED FOR REVIEWING GOALS AND PRIORITIES

There are a few here better qualified to discuss and review the opportunities of space than you. But we have to review the priorities and perhaps redefine the goals; if nothing else, the budget impact of the accident forces a review of how far we have come and where we have to go.

It is really funny, but I guess it was in my days in the military, which were so long ago it almost fades from memory, that the world had its first exposure to that kind of propulsion that ultimately led us into space. It was on the other side, unfortunately, of the forces. Lots of rockets passed overhead. I couldn't see them in flight, but you could see the results. Those days saw the beginnings of the jet-propelled engine, the jet engine, and jet-propelled aircraft.

I watched Messerschmitts fly in Belgium when they first were flying these things. Mankind was little aware of what was to follow in the years ahead. That research proved, notwithstanding the goals of its developers, ultimately to have some very positive results. I am pleased that we are here exploring the opportunities and the possibilities, Mr. Chairman, and I look forward to hearing from the witnesses and the opportunity to discuss issues with them later on.

Senator GARN. Thank you, Senator.

McDONNELL DOUGLAS CORP.

STATEMENT OF ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY GENERAL MANAGER, McDONNELL DOUGLAS AERONAUTICS CO.

Senator GARN. Mr. Hood?

Mr. HOOD. Thank you, Mr. Chairman, Senator Lautenberg.

I appreciate the opportunity to appear before the subcommittee today to speak on the subject of our confidence in this Nation's space program. I would like to start by making a point.

As you know, Mr. Chairman, we have just finished visiting about 80 Members of the Congress for the purpose of reemphasizing the importance of maintaining U.S. leadership in civil space development.

They have given us a resounding message: The space program is alive and well. It did not stop with *Challenger*.

The *Challenger* accident was a tremendous loss which could be likened to losing a member of the family. It is painful, of course, and forces us to readjust, but the family lives and goes on functioning. The space program is alive and will go on functioning, because the space program is much bigger than *Challenger* or the space transportation system or any other of its individuals parts.

COURAGE OF ASTRONAUTS CITED

As Joe pointed out, the *Challenger* astronauts believed in the vitality and importance of the whole program. They knowingly and willingly accepted the risks of space flight. Last week, Barbara Morgan, the teacher backup to Christa McAuliffe, confirmed that. She said that Dick Scobee told teacher-in-space candidates that a catastrophic accident would take place one day. Barbara Morgan is fully aware of the risks and says when NASA is ready to fly, she will be ready to fly.

It is vital that we make sure that Christa McAuliffe from the *Challenger* crew did not die in vain, that we honor their commitment and their sacrifice by carrying on their work.

That work, as Joe Allen also pointed out, was part of a very carefully thought out and well planned space program.

The space program is a product of some of the most capable and experienced technical and managerial minds this country has to offer. Its engineers have painstakingly developed the program from the sixties, when they first put men in space and implemented President Kennedy's directive to put man on the Moon in the seventies, when they orbited the Skylab, the first space station, and built the first space shuttle for the then heavy payloads between Earth and low-Earth orbit.

STRONG PRESIDENTIAL LEADERSHIP

In 1961, as you will recall, during a time of crisis regarding our space program in relation to the Russians, President Kennedy appointed Vice President Johnson to coordinate the U.S. civil space program direction. Mr. Johnson chaired the National Space Council, which was provided for under title 2, section 201, of the National Space Act of July 29, 1958. The Vice President and the Council actively drove the President's space policy, providing the link between the President and the program itself. That linkage is clearly necessary if the President's directives are to take shape and be carried out.

As you are well aware, Mr. Chairman, President Reagan has made clear on numerous occasions his strong commitment to civil space endeavors and his desire to leave a free world space station as a nonmilitary legacy. This desire will be in jeopardy, without strong leadership at the highest administrative levels.

REINSTITUTION OF NATIONAL SPACE COUNCIL RECOMMENDED

I strongly recommend that we reinstitute the National Space Council, which grew so fruitful during NASA's fast-moving and highly successful development years, and that we do so as soon as possible. It will signal our international partners that the U.S. commitment to space station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative space station program.

It also will signal the private sector here in the United States that the future investment in commercial space activities can be planned, and it will signal U.S. industry that the space station program is on track and that its own investment of money and talent need not be redirected to other programs.

The effect of the unfortunate *Challenger* accident ultimately will be to revitalize the space program. NASA and its contractors and industry will come forth with renewed energy and improved knowledge to strengthen elements shown to be weak and to fix the discovered problems. The result will be a better and stronger shuttle and a better and stronger space program. That is the nature of research and development and flight testing, which are fundamental purposes of NASA.

In the past couple of years, U.S. space planners have taken bold and innovative first steps into the commercialization of space. The fruits of this undertaking are without limit in potential. Our work in the area will produce new technologies and spinoffs; it will enrich the lives of consumers and create commercial space industries amounting to billions of dollars. It will confirm and expand our country's leadership in space, enabling us to compete effectively with other nations which are rapidly working to develop commercial space markets.

CONTRIBUTION OF McDONNELL DOUGLAS TO SPACE PROGRAM

The implementation of space station will allow us to complete a total space infrastructure supported by the shuttle. The shuttle has been a good test bed for space station, demonstrating that we, in fact, can use the weightlessness of space to produce medicines and materials impossible or too costly to the manufacturer on the ground. At McDonnell Douglas, we have accumulated a wealth of knowledge in this area with our shuttle electrophoresis experiment. But the shuttle is in orbit for too short a time and has too little space in its cargo bay to offer commercial manufacturing. Commercial space manufacturing requires a permanently based facility.

We also have been working closely with other companies to develop specifications for manufacturing in space and to implement long-term production aboard the station. Numerous plans already exist for conducting commercial manufacturing and scientific research on a long duration basis, plans that require a space station for fruition.

INTRODUCTION OF ASTRONAUTS

We at McDonnell Douglas are fortunate to have two experienced astronauts with more than 1,600 hours in space between them working to develop a space station and its potential. I have both men here today to share with you some relevant aspects of their experience.

First, I would like to introduce Pete Conrad. Mr. Conrad flew in Geminis V and XI, Apollo XII and Skylab, and has 1,174 hours in space. Skylab entailed the extended duty tour in a space working environment that will be characteristic of the space station. No one is better equipped to describe what a man can do in long-term space operations than Pete. Pete is also acquainted with the Soviet space program and can describe something of their approach.

When Pete has completed his statement, Charlie Walker will testify.

Charlie, your crew companion, Mr. Chairman, has flown on three space shuttle flights. He is a specialist in the electrophoresis experiment and has more experience in space processing than any other person in the program. Charlie is also uniquely qualified to talk about materials processing in space and the potential of space for commercial manufacturing.

[The statement and questions and answers follows:]

STATEMENT OF ROBERT H. HOOD, JR., VICE PRESIDENT AND DEPUTY GENERAL MANAGER, MCDONNELL DOUGLAS ASTRONAUTICS CO.

Mr. Chairman and Distinguished Members of the Subcommittee:

Thank you for the opportunity to appear before the Subcommittee today to speak on the subject of our confidence in this nation's Space Program. I'd like to start by making a key point. We have just finished visiting about eighty members of Congress for the purpose of re-emphasizing the importance of maintaining U.S. leadership in civil space development. They have given us a resounding message. The Space Program is alive and well. It did not stop with Challenger.

The Challenger accident was a tremendous loss which can be likened to losing a member of the family. It is painful and it forces us to readjust, but the family lives and goes on functioning. The Space Program is alive and will go on functioning, because the Space Program is much bigger than Challenger, or the Space Transportation System, or any other of its individual parts.

The Challenger astronauts believed in the vitality and importance of the whole Program. They knowingly and willingly accepted the risks of space flight. Last week, Barbara Morgan, the teacher back-up to Christa McAuliffe, confirmed that. She said that Dick Scobee told Teacher-in-Space candidates that a catastrophic accident would take place one day. Barbara Morgan is fully aware of the risks, and says that when NASA is ready to fly she will be ready to fly.

It is vital that we make sure Christa McAuliffe and the Challenger crew did not die in vain -- that we honor their commitment and their sacrifice by carrying on their work.

That work was part of a very carefully thought out and well planned Space Program. The Space Program is the product of some of the most capable and experienced technical and managerial minds this country has to offer. Its engineers have painstakingly developed the Program from the sixties, when they first put men in space and implemented President Kennedy's directives to put man on the Moon, to the seventies, when they orbited Skylab -- the first Space Station -- and built the first Space Shuttle to ferry men and heavy payloads between earth and low earth orbit.

In 1961, during a time of crisis regarding our Space Program in relation to the U.S.S.R.'s, President Kennedy appointed Vice President Johnson to coordinate the U.S. Civil Space Program direction. Mr. Johnson chaired the National Space Council that was provided for under Title 2, Section 201 of the National Space Act of July 29, 1958. The Vice President and the Council actively drove the President's space policy, providing the link between the President and the Program itself. That link is clearly necessary if the President's directives are to take shape and be carried out.

President Reagan has made clear on numerous occasions his strong commitment to civil space endeavors and his desire to leave a free world Space Station as a non-military legacy. This desire will be in jeopardy without strong leadership at the highest administrative level.

I strongly recommend that we reinstitute the National Space Council, which proved so fruitful during NASA's fast-moving and highly successful developmental years, and that we do so as soon as possible. It will signal our international partners that the U.S. commitment to Space Station is firm and that their own budgetary and intellectual resources can safely and productively be devoted to a cooperative Space Station Program. It also will signal the private sector here in the U.S. that future investment in commercial space activities can be planned and it will signal U.S. industry that the Space Station program is on track and that its own investment of money and talent need not be redirected to other programs.

The effect of the unfortunate Challenger accident ultimately will be to revitalize the Space Program. NASA and its contractors in industry will come forth with renewed energy and improved knowledge to strengthen elements shown to be weak and to fix the discovered problems. The result will be a better and stronger Shuttle and a better and stronger Space Program. That is the nature of research and development and flight testing -- which are fundamental purposes of NASA.

In the last couple of years, U.S. space planners have taken bold and innovative first steps into the commercialization of space. The fruits of this undertaking are without limit in potential. Our work in this area will produce new technologies and spinoffs which will enrich the lives of consumers and create commercial space industries amounting to billions of dollars. It will confirm and expand our country's leadership in space, enabling us to compete effectively with the other nations which are working rapidly to develop commercial space markets.

The implementation of Space Station will allow us to complete a total space infrastructure supported by the Shuttle. The Shuttle has been a good testbed for the Space Station -- demonstrating that we can use the weightlessness of space to produce medicines and materials impossible or too costly to manufacture on the ground. At McDonnell Douglas we have accumulated a wealth of knowledge in this area with our Shuttle Electrophoresis Experiment. But the Shuttle is in orbit for too short a time and has too little space in its cargo bay to offer manufacturing capability. Commercial space manufacturing requires a permanently based facility.

We have also been working closely with other companies to develop specifications for manufacturing in space and to implement long term production aboard the Station. Numerous plans already exist for conducting commercial manufacturing and scientific research on a long duration basis -- plans that require Space Station for fruition.

McDonnell Douglas is fortunate to have two experienced astronauts, with more than sixteen-hundred hours in space between them, working to develop the Space Station and its potential. I have both men here today to share with you some relevant aspects of their experience.

First, I'd like to introduce Pete Conrad. Mr. Conrad flew on Geminis five and elevan, Apollo twelve, and Skylab, and has eleven-hundred seventy-four hours in space. Skylab entailed the extended duty tour in a space working environment that will be characteristic of Space Station. No one is better equipped to describe what a man can do in long duration space operations than Pete. Pete also is acquainted with the Soviet space program and can describe something of their approach.

When Pete has completed his statement, Charlie Walker will testify.

Charlie Walker has flown on three Space Shuttle flights. He is a specialist in the Electrophoresis Experiment and has more expertise in space processing than any other person in the Program. Charlie is also uniquely qualified to talk about material processing in space and the potential of space for commercial manufacturing.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE D'AMATO

INDUSTRIAL UTILIZATION OF SPACE TECHNOLOGY

Question: The Washington Post (Monday, March 24, 1986, page A4) reported "Shuttle Inquiry Criticized by Industry Engineers -- Fear Voiced Probe is Becoming a 'Witch Hunt'." What is the position of the industries represented today concerning the status of the Shuttle investigation?

Answer: The technical and management procedures as they relate to the Shuttle accident should be thoroughly and objectively investigated. But, speculation as to the reasons for the failure should not be stated in the press or otherwise until all the information has been gathered and analyzed. To do otherwise could have a long lasting and demotivating effect on NASA and its future ability to attract young innovative talent to manage our future space efforts.

Question: The industries represented today might want to elaborate on the status of the private sector involvement in the space program and the recommendations they might have for the future of this program. In particular, is there a need for further development of the Expendable Launch Vehicles (ELVs), as well as the Space Shuttle Program? Or is it better to focus more attention on one, rather than both?

Answer: At McDonnell Douglas we always believed there is a need to have a mixed fleet of expendable launch vehicles to complement the Shuttle. The loss of the Challenger now makes it mandatory that we proceed in that direction.

MDAC has examined the question of commercializing Delta a number of times over the past several years. Based on competitive experience since 1978 in the world launch market, we have learned that a commercial organization cannot compete with government sponsored launch vehicles. The commercial risks are far greater than can be accepted. These risks are:

- Large production start-up costs
- Continuing uprating investments to remain competitive
- Reserves for failures and adversity
- Unavailable insurance or extremely high insurance costs
- Foreign competitors flexibility on pricing/financing
- U.S. government policy shifts

On the other hand, a government sponsored mixed fleet approach can easily be put in place by extending current ELV contracts. There was a period in the early 1980's where NASA operated a mixed fleet in a very similar manner, so we have been there before. This approach is the only way that the U.S. can be positive that a diversified ELV industrial base will remain in the United States and that a complementary launch capability to the Shuttle will be available to assure future access to space under any adversity.

STATEMENT OF "PETE" CONRAD, JR., CORPORATE VICE PRESIDENT, McDONNELL DOUGLAS CORP.

Senator GARN. Pete?

Mr. CONRAD. Thank you.

Senator GARN. Pete, we are happy to have you with us today. I would only make one comment: Both of us have been terribly disappointed that hair wouldn't grow in a weightless environment. [Laughter.]

We had really hoped that without gravity, it would just spring right out of the follicles, but it didn't do so. [Laughter.]

Mr. CONRAD. No such luck.

SPUTNIK TRIGGERED SPACE EFFORT

Mr. Chairman and distinguished members of the subcommittee, it is also my pleasure to be here today. I would like to start out by saying the early emphasis and focus on space in this country began when the Russians put Sputnik in orbit. We came on with Projects Mercury and Gemini and, thanks to the direction of President Kennedy, succeeded in putting man on the Moon. This put us on the leading edge of continued advancement in the future development in space. We launched and operated the prototype for a permanently manned space lab in Skylab, where we worked, lived, and performed our first long-duration science experiments in space.

However, we tend to forget the work, and I should say study work, that was done in the early sixties which looked at man on Mars and permanently manned space stations in the eighties. Because of underlying political developments of the time, the inclination of our leaders shifted away from space, and these studies were shelved. The shuttle, which had its inception during this period, was often in jeopardy and strained to the limit by funding cuts and stretchouts. It was intended to be operational in 1978, but it did not come on line until 1981.

At the same time, the Soviets continued steadily to advance their space program. Launching their cosmonauts on Soyuz, the Soviets put their long-duration Salyut space station, on which they accumulated an impressive record of man hours and established a permanent presence of Russians in space. They wanted to have flown two flights in excess of 150 days. Another individual has a longer duration in record of 234 days, and he is back up again right now.

It also appears that they are developing, in parallel, a shuttle-type system which may not be far from going into operation.

So the factors which initially triggered NASA's progress in space have escalated significantly since we walked on the moon. Last month, the Soviets presented to the world their successful launch of Mir, the first laboratory module of a permanently manned advanced Soviet space station devoted to astronomical, biological, and technological experimentation.

These are precisely the types of work we expect to perform on the U.S. space station after we build it in the 1990's. Mir, the name which the Soviets have given their new manned station, has been translated as meaning "peace," but in the Russian venacular, Mir also means "world." The Soviets have every intention of establishing and operating new worlds in space.

In 1975, I traveled for a good period of time with Cosmonaut Vitaliy Sevastyonov and got to know him fairly well. I think that the statements he made during a recent interview on Soviet television are very revealing with regard to Soviet intentions.

Sevastyonov described applied research missions in space done under contracts with various departments and agencies as having begun to pay off 10 years ago. He said that after comparing costs of the same work done on Earth, a special commission concluded that the space operations paid off. He went on to say that modern space missions enable the Soviets to make a profit and because of this, they are becoming an integral part of the Soviet economy.

But the crux of Sevastyonov's statement was this, and I will quote him, because it says so much about their intentions, and I quote:

> Space technology offers great opportunities for intensified production in various economic sectors. Many of these have received a commercial payoff from relying on space programs. This country will be able to greatly boost its economy by using space to develop new technology, to forecast weather and conduct remote sensing, and by making the results of these efforts easily available throughout the country. To this end, the Soviet Union is working on new spacecraft.

In other words, the Soviets are expanding into all of the same areas which we expect to develop in space, including commerce. Space is going to be a whole new marketplace, and the Russians are already in it.

The Russians are not the only ones, either. A number of other nations are involved actively in today's commercial space race, both in cooperation with NASA and independently. The Europeans, the Japanese, and, most recently, the Chinese are studying and developing new launch strategies, transportation schemes, space station designs, commercial ventures, and scientific and military programs.

The French have announced that they are making their Hermes vehicle, which is going to be a minishuttle, compatible with the Soviet station Mir. The market is wide open and we are going to have to work hard to stay in it. Unless we get our own space program back on track, we stand to lose on a global scale, economically and technologically, militarily and politically. We have to learn from the Challenger tragedy, apply what we learn to the future, and go forward.

Thank you.

Senator GARN. Thank you, Pete.

[The statement and questions and answers follow:]

STATEMENT OF C. "PETE" CONRAD, CORPORATE VICE PRESIDENT, McDONNELL DOUGLAS CORP.

Mr. Chairman and Distinguished Members of the Subcommittee:

The early emphasis and focus on space in this country began when the Russians put Sputnik in orbit. We came on with projects Mercury and Gemini and, thanks to the direction of President Kennedy, succeeded in putting man on the Moon. This put us on the leading edge of continued advancement in the future development in space. We launched and operated the prototype for a permanently manned space station in Skylab, where we worked, lived and performed our first long duration science experiments in space.

However, we tend to forget the work done in the early sixties, which looked at man on Mars and permanently manned space stations in the eighties. Because of underlying political developments of the time, the inclination of our leaders shifted away from space, and these studies were shelved. The Shuttle, which had its inception during this period, was often in jeopardy and strained to the limit by funding cuts and stretch-out. It was intended to be operational in seventy-eight but did not come on line until eighty-one.

At the same time, the Soviets continued steadily to advance their space program. Launching their cosmonauts and modules on Soyuz, the Soviets put together their long duration Salyut space station -- on which they accumulated an impressive record of man hours and established a permanent presence of Russians in space. It also appears that they are developing in parallel a shuttle type system which may not be far from going into operation.

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But the crux of Sevastyanov's statement was this -- and I'll quote him, because it says so much about their intentions: "Space technology offers great opportunities for intensified production in various economic sectors. Many of these have received a commercial payoff from relying on space programs. This country will be able to greatly boost its economy by using space to develop new technology, to forecast weather and conduct remote sensing, and by making the results of these efforts easily available throughout the country. To this end the Soviet Union is working on new spacecraft."

In other words, the Soviets are expanding into all of the same areas which we expect to develop in space -- including commerce. Space is going to be a whole new marketplace; and the Russians already are in it.

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Unless we get our own Space Program back on tract, we stand to lose on a global scale -- economically and technologically; militarily and politically. We have to learn from the Challenger tragedy, apply what we learn to the future and go forward.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE D'AMATO

SHUTTLE INVESTIGATION

Question: The Washington Post (Monday, March 24, 1986, Page A4) reported "Shuttle Inquiry Critized by Industry Engineers -- Fear Voiced Probe is Becoming a 'Witch Hunt'." What is the position of the industries represented today concerning the status of the shuttle investigation?

Answer: The Presidential Commission is investigating the Challenger accident in a rigorous and orderly manner. The Commission has adequate technical support groups that should be able to provide all the necessary data and facts. The Commission should be able to reach valid conclusions as to the specific events and causes of the accident.

ELVs AND/OR SHUTTLE

Question: The industries represented today might want to elaborate on the status of the private sector involvement in the space program and the recommendations they might have for the future of this program. In particular, is there a need for further development of the Expendable Launch Vehicles (ELVs), as well as the Space Shuttle program? Or is it better to focus more attention on one, rather than both?

Answer: ELVs will be required to alleviate the log jam of payloads that will build up over the time period the shuttle fleet is grounded. The total number needs to be determined by the size of the shuttle fleet, the length of time the fleet is grounded and the projected flight schedule build-up rate.

The more important question will be the cost of ELV launches for commercial payloads. The United States will have to decide on subsidizing some portion of these costs to preclude the commercial payloads being launched totally on foreign government subsidized ELVs which are currently available.

STATEMENT OF CHARLES D. WALKER, EOS CHIEF PROGRAM ENGINEER AND PAYLOAD SPECIALIST, McDONNELL DOUGLAS CORP.

Senator GARN. Charlie?

Mr. WALKER. Thank you, Mr. Chairman, Senator Lautenberg, invited guests. I am very pleased to have the opportunity today to testify before the subcommittee to express my confidence in this Nation's manned space program and to encourage your continued efforts toward a manned space station.

I join my colleagues here today in their support of the National Aeronautics and Space Administration and as a three-time payload specialist, a working passenger on this Nation's space transportation system, I represent a thrust into the blossoming new industrial age of opportunity.

Space is a place beyond our normal experience, a place far more vast than we can imagine. The shelter of the Earth's environment limits our perspectives, so much so that we fail to recognize that space encompasses virtually all of creation. The space shuttle opens a door into that vast expanse of creation and into a new age without limits.

Limits, real and perceived, kept our old world forefathers insulated and isolated. Only bold ideas, clever deductions and brave investments of both wealth and people led to the timely discovery of this new world. That European age of discovery was fueled, in very simple terms, by political and religious motives, but sustained and shaped by economic forces.

RISE OF ECONOMIC MOTIVES

May I suggest that today, our age of opportunity is, in principle, much the same. Twenty-five years ago, the drive to get into space was highly emotional and, yes, political. But increasingly, over the past decade, a realization developed in the private sector of our economy in this country that there were, in fact, economic motives for visiting and, in fact, for staying awhile in outer space.

Again, it is bold ideas, clever deductions, and brave investments that promise to fuel a new industrial age. NASA is the force behind these actions.

Through technology developed for NASA and fostered initially by a unique financial creation, the Communications Satellite Corp., communications via satellite has earned this mature industry revenues in the billions of dollars. From other NASA technology, commercial remote sensing ventures are moving toward profitability. Today's innovative ideas for space-based industry may need greater care and nurturing and perhaps more patience than it took to make satellite communications profitable.

And NASA has been working to make it possible. NASA has long sponsored the open transition and transfusion of technology derived from public funds into academia and industry, and likewise, NASA has encouraged direct industrial involvement in NASA-sponsored research and development.

Because the space transportation system offers unparalleled access to space, NASA developed other vehicles, specifically, policies and working relationships, to aid industry in taking the plunge with reasonable investment risk.

NASA PROVIDES INCENTIVES

NASA, recognizing that any private firm or public company has limited resources, is helping manage the amount of risk associated with these efforts, and NASA is vigorously pursuing its role within Government to encourage a growing technical consumer society. Just as this Government provided incentives 150 years ago to expand beyond the Mississippi River, so NASA, as an arm of this Government today, is making available an exchange of service agreements and delayed launch services payments to reduce but not to eliminate the financial risks of commercializing space.

McDonnell Douglas has utilized the space shuttle as a laboratory in which to explore the possibility of unique life-saving pharmaceuticals.

Senator Garn, you observed my company's work on board your own flight. McDonnell Douglas has accepted the financial risk of many tens of millions of dollars involved in creating a manufacturing and purification process that exploits that unique weightless environment of Earth orbit.

But I must say that the road to these new business activities is a rough one for every one of the many companies looking to space. More needs to be done. A basic necessity for industry planning is consistency in Federal support of the space shuttle and the next logical step, the free world space station.

My 475 hours of research and development aboard the space shuttle were invaluable, and it is McDonnell Douglas' experience that particularly for materials processing, direct human presence is not just practical but economical. My work could have been even more productive for McDonnell Douglas and NASA if I could have worked in a dedicated, long-term facility. The manned Space Station will provide this opportunity, and I personally hope to work there in the near future.

Many technically and economically capable countries participated in the age of discovery. Only a few had the leadership and determination to gain for themselves from that opportunity. Today, many countries, East and West, as my colleague Pete Conrad has pointed out, are positioning their futures in space. The leadership and the determination demonstrated by NASA is leading the United States into this age of opportunity.

We see the future unfolding above us. To deny it is to chain ourselves to a tomorrow of diminishing choices, and chains that don't suit us. Tomorrow is ours out there.

Thank you very much.

Senator GARN. Thank you, Charlie.

[The statement and questions and answers follow:]

STATEMENT OF CHARLES D. WALKER, EOS PROGRAM CHIEF TEST ENGINEER AND PAYLOAD SPECIALIST, MCDONNELL DOUGLAS ASTRONAUTICS CO.

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QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE M. D'AMATO

Electrophoresis In Space

Question: Are there any plans for future research in space, for example, using Electrophoresis in Space capabilities? If so, what are some of the activities that you have planned and the proposed benefit to our Nation?

Answer: Yes, sir. McDonnell Douglas Astronautics Company has signed an extention to our Electrophoresis Joint Endeavor Agreement that calls for up to 15 flights of our research and development payload over the next 5 years. Half of the time on-orbit, under this agreement, will be for research with NASA experiments. This unique research will be as varied as NASA decides to sponsor. It will be research, probably largely in the medical field, that will save NASA millions of dollars because the apparatus has been built and maintained by McDonnell Douglas privately. It may, in fact, be research that would not have been performed otherwise because of Federal budget constraints. For its investment McDonnell Douglas will have the opportunity to continue electrophoresis technology development in space and research purification improvements with new commercial pharmaceuticals.

AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

STATEMENT OF DR. KARL G. HARR, JR., PRESIDENT

Senator GARN. Dr. Harr?

Dr. HARR. Mr. Chairman, the Aerospace Industries Association is the trade association representing the Nation's major manufacturers of commercial, military, and business aircraft, helicopters, aircraft engines, missiles, spacecraft, and related components and equipment.

We greatly appreciate the subcommittee's invitation to appear here today to discuss industry's perspective on the benefits associated with the U.S. space program. This industry has had the unique opportunity of being NASA's principal partner in this effort, and we have enjoyed the enormous satisfaction of contributing to extensive technological, scientific, and economic benefits that this partnership has produced.

Our national space effort has, indeed, had a tremendous impact on the totality of American life, economically, politically, and spiritually. In the beginning and during the early years of that effort, one could reasonably speculate, pro and con, as to the overall benefits of our space program, but today, after nearly 30 years, nobody can responsibly refute the fact that:

BENEFITS OF SPACE EFFORT

One, there is a direct and beneficial relationship between our space effort and the strength and growth of the overall economy;

Two, there is a direct and beneficial relationship between our space effort and our standing among the peoples of the world;

Three, there is a direct and beneficial relationship between our national space efforts and our national survival; and

Four, there is a direct and beneficial relationship between that effort and our capacity to address ourselves effectively to all national needs.

Our space effort, for example, virtually transformed American high technology industry and by so doing, was certainly a major, if not the major, factor in establishing and sustaining U.S. high technology preeminence, upon which both our competitive success in international trade and our national security have been largely based for the past two or three decades.

Much of this, of course, has been fully appreciated along the way. The direct benefits for communication, navigation resource exploration, soil, crop, and water conservation, greatly improved meteorology and the like, for example, are there for all to see. The so-called spinoffs and indirect benefits, including not only many end products, but the creation of new materials such as advanced alloys, composites, computer miniaturization, and the like are also generally well known.

Then, too, all of us have heard much, particularly recently, about the manufacturing, materials processing and pharmaceutical production that can only be carried out in a low-gravity environment.

The order of magnitude increase and scientific knowledge produced by our space program by, for example, functioning vehicles escaping our solar system system is so overwhelming in its scope and drama as to greatly impress not only the layman, but all of us. Such miracles are not confined to our own endeavors. The images taken inside Halley's Comet, for example, represent a European achievement.

Finally, many of us understand the improved scientific, technological, and production capability the space effort has produced, such as radically improved diagnostic and health monitoring capabilities, a wide variety of productivity enhancing processes and the revolution in computer development driven by the space program's insatiable need for computation and data storage capability.

The appreciation of such benefits has not been limited to our own country. From around the world, we have heard loud reaffirmation, sometimes admiring, sometimes accusing, of the advantages this Nation has derived as a result of the space efforts.

In the early years, before most of the rest of the world had the capacity to emulate our efforts, such reaffirmation was largely vocal. Today, and for many years now, it has taken the hard form of fiercely competitive emulation and a steadily accelerating chain of successful achievement.

On the other hand, two equally important benefits that seem to be less appreciated, perhaps because they are less measurable, are the impact our space effort has had on the standards level and systems management capability of American industry.

MAN RATING

Man rating, meaning producing reliability and performance sufficient to protect man in the cruel environment of space, meant upgrading virtually everything in the industrial process. Manufacturing tolerances had to be reduced by orders of magnitude, just as reliability requirements had to be commensurately upgraded.

With respect to upgrading our systems management capabilities, the major space programs, particularly the Apollo program which can be safely described as the greatest organized technological reach in the history of mankind, introduced whole new sets of management concepts.

CONTRIBUTION TO OVERALL ECONOMY

As both the new standards levels and the improved systems management capabilities spread into American management as a whole, they inevitably made an enormous contribution to our overall economy.

And of course they spread throughout American industry. It is difficult for me to understand those who cannot grasp that this result was certain to occur, those who believe that it is possible to reach way out in front technologically in one major area and not have the effect of that reach felt across the board. Do they really believe that scientists, engineers, and managers in other areas are not going to avail themselves of new scientific knowledge, new alloys, and new ways of working, new inventions, new devices for refining tolerances and upgrading standards, new techniques for radically improving management?

Do they really believe that these new and advanced things required to be taught and learned in graduate schools and research centers and industry will be put to use only by those who go into aerospace careers? Of course, history has always proven the converse to be true. The effect of research and developing new muscle and sinew in a particular focus of technological advance has always proved, sooner or later, to be all pervasive. I think it can be understood perhaps most sharply if you think of what would happen if we tried not to have it leak out, tried to contain it in this society.

This fact, obviously, had much to do with U.S. success in the world marketplace since World War II, at least insofar as high-technology products are concerned. Most of us also appreciate that there is another enormous intangible in all of this. You may describe it differently and put different values on it, but the impact of a nation's decision to go forward toward new frontiers and to successfully implement that decision has immeasurable value in terms of raising our national spirits, hopes and aspirations in terms of serendipity, and in the opportunity it gives our youth to look forward, upward, and outward.

For many, this last intangible is far from the least important result of our space effort. Finally, I have discussed the boost our space program has given to our overall economy and have touched on the zeal with which our industrial competitors are endeavoring, with considerable success, I might add, to close the gap between us. In this context, it is pertinent to mention one of the most exciting prospects in the continuing

U.S. effort to exploit the economic and scientific potential of aeronautics and space—the currently contemplated National Aerospace Plane Research Program. This transatmospheric research and technology advancement effort could pave the way for later development of a whole family of airbreathing, horizontal takeoff, hypersonic vehicles capable of accelerating directly to orbit or operating within the upper atmosphere at unprecedented speeds.

Successful development of the essential technologies would make possible, for military space operations, rapid access to space as required and expanded maneuverability in orbit; for civil and military space operations, a dramatic reduction in the costs of delivering payloads; for military aircraft operations, a new class of highly survivable hypersonic reconnaissance or interceptor airplanes; and for civil air transportation, passenger-carrying vehicles operating above 100,000 feet at velocities of 4,000 miles per hour or more. The implications for U.S. defense capability and trade competitiveness in the 21st century are stunning.

The space program, Mr. Chairman, in short, is not an optional endeavor for the United States. It is an inextricable and critical element in the continuing prosperity of our economy and society. The decisions we make today about how vigorously we as a nation can respond to the new challenges of space will expand or constrict future generations' ability to fulfill their own aspirations. Perhaps that alone, Mr. Chairman, is the single most important justification for pushing harder and farther into the frontiers of space.

Thank you.

[The statement follows:]

STATEMENT OF KARL G. HARR, JR., PRESIDENT, AEROSPACE INDUSTRIES ASSOCIATION OF AMERICA, INC.

Mr. Chairman and Members of the Subcommittee:

I am Karl G. Harr, Jr., President of the Aerospace Industries Association of America, Inc. (AIA), the trade association representing the nation's major manufacturers of commercial, military and business aircraft, helicopters, aircraft engines, missiles, spacecraft and related components and equipment. I appreciate the Subcommittee's invitation to appear here today to discuss industry's perspective on the benefits associated with the U. S. space program. The aerospace industry has had the unique opportunity of being NASA's principal partner in this effort, and we have enjoyed the enormous satisfaction of contributing to the extensive technological, scientific and economic benefits that this partnership has produced.

Our national space effort has indeed had a tremendous impact on the totality of American life -- economically, politically, and spiritually. In the beginning and during the early years of that effort one could reasonably speculate pro and con as to the over-all benefits of our space program, but today, after 30 years, nobody can responsibly refute the fact that:

1. There is a direct and beneficial relationship between our space effort and the strength and growth of our overall economy.
2. There is a direct and beneficial relationship between our space effort and our standing among the peoples and the nations of the world.
3. There is a direct and beneficial relationship between our national space effort and our national survival.
4. There is a direct and beneficial relationship between that effort and our capacity to address ourselves effectively to all national needs.

Our space effort, for example, virtually transformed American high technology industry, and by so doing, was certainly a major, if not the major, factor in establishing and sustaining U. S. high technology preeminence -- upon which both our competitive success in international trade and our national security have been largely based for the past two or three decades.

Much of this of course, has been fully appreciated along the way. The direct benefits to communication, navigation, resource exploration, soil, crop and water conservation, greatly improved meteorology and the like, for example, are there for all to see. The so-called spin-offs and indirect benefits, including not only many end products but the creation of new materials such as advanced alloys, composites, computer miniaturization and the like, are also generally well known.

Then, too, all of us have heard much about the manufacturing, materials processing and pharmaceutical production that can only be carried out in a low-gravity environment.

The order of magnitude increase in scientific knowledge produced by our space program by, for example, functioning vehicles escaping our solar system is so overwhelming in its scope and drama as to greatly impress not only the layman, but all of us. And the miracles are not confined to our own endeavors. The images taken inside Halley's Comet, for example, represent a European achievement.

Finally, most of us at least generally understand the improved scientific, technological and production capability the space effort has produced, such as radically improved diagnostic and health monitoring capabilities, a wide variety of productivity-enhancing industrial processes, and the revolution in computer development driven by the space program's insatiable need for computational and data storage capability.

Appreciation of such benefits has not been limited to our own country. From around the world we have heard loud reaffirmation, sometimes admiring, sometimes accusing, of the advantages this nation has derived as a result of its space effort.

In the early years, before most of the rest of the world had the capacity to emulate our efforts, such reaffirmation was largely vocal. Today and for many years now, it has taken the hard form of fiercely competitive emulation and a steadily accelerating chain of successful achievement.

On the other hand, two equally important benefits that seem to be less appreciated, perhaps because they are less measurable, are the impact our space effort has had on the standards level and systems management capability of American industry.

"Man-rating" -- meaning producing reliability and performance sufficient to protect man in the cruel environment of space -- meant upgrading virtually everything in the industrial process. Manufacturing tolerances had to be reduced by orders of magnitude just as reliability requirements had to be commensurately upgraded.

With respect to upgrading our systems management capabilities, the major space programs -- particularly the Apollo Program, which can be safely described as the greatest organized technological reach in the history of mankind -- introduced whole new sets of management concepts.

As both the new standards levels and the improved systems management capabilities spread into American industry as a whole, they inevitably made an enormous contribution to our overall economy.

And of course they spread throughout American industry. It is difficult for me to understand those who cannot grasp that this result was certain, who believe that it is possible to reach way out in front technologically in one major area, and not have the effect of that reach felt across the board. Do they really believe that scientists, engineers and managers in other areas are not going to avail themselves of new scientific knowledge, new alloys and new ways of working them, new inventions, new devices for refining tolerances and upgrading standards, new techniques for radically improving management? Do they really believe that those new and advanced things required to be taught and learned in graduate schools and research centers and industry will be put to use only by those who actually go into aerospace careers?

History has always proved the converse to be true. The effect of straining, reaching and developing new muscle and sinew in a particular focus of technological advance has always proved, sooner or later, to be all pervasive.

This fact obviously had much to do with U.S. success in the world marketplace since World War II, at least insofar as high technology products are concerned.

Most of us appreciate that there is also an enormous intangible in all this. We may describe it differently and put different values on it, but the impact of a nation's decision to go forward toward new frontiers, and successfully implement that decision, has immeasurable value in terms of raising our national spirits, hopes and aspirations, in terms of serendipity, and in the opportunity it gives our youth to look forward, upward and outward. For many, this last intangible is far from the least important result of our space effort.

Finally, I have discussed the boost our space program has given to our overall economy, and I have touched on the zeal with which our industrial competitors are endeavoring, with considerable success, to close the gap between us. In this context it is pertinent to mention one of the most exciting prospects in the continuing U.S. effort to exploit the economic and scientific potential of aeronautics and space -- the currently contemplated National Aerospace Plane research program. This transatmospheric research and technology advancement effort could pave the way for later development of a whole family of airbreathing, horizontal takeoff, hypersonic vehicles capable of accelerating directly to orbit or operating within the upper atmosphere at unprecedented speeds. Successful development of the essential technologies would make possible, for military space operations, rapid access to space as required and expanded maneuverability in orbit; for civil and military space operations, a dramatic reduction in the costs of delivering payloads to orbit; for military aircraft operations, a new class of highly survivable hypersonic reconnaissance or interceptor airplanes; and for civil air transportation, a passenger-carrying vehicle operating above 100,000 feet at velocities of 4,000 miles per hour or more. The implications for U. S. defense capability and trade competitiveness in the 21st century are stunning.

The space program, in short, is not an "optional" endeavor for the United States -- it is an inextricable and critical element in the continuing prosperity of our economy and society. The decisions we make today about how vigorously we as a nation will respond to the new challenges of space will expand or constrict future generations' ability to fulfill their own aspirations. Perhaps that alone, Mr. Chairman, is the single most important justification for pushing harder and farther into the frontiers of space.

LACK OF UNDERSTANDING AND BUDGET CUTS CITED

Senator GARN. Thank you, Mr. Harr.

Gentlemen, I suppose my greatest frustration in trying to look at where we go in the future with our space program is looking at the past and what a great lack of understanding there is in what space has already done for us. When I first came to the Senate over 11 years ago, I was assigned to the original Space Committee when it was still a separate authorizing committee before it was made a subcommittee of Commerce.

I can remember at that time Frank Moss, my senior colleague from Utah was the chairman; Jim Fletcher was the Administrator of NASA. I can remember sitting in the last seat over there as the most junior member of that committee when the committee promised Jim Fletcher and NASA that we could keep NASA whole from inflation. We had tight budget problems back in 1975, but nevertheless, we would at least make sure that they did not have a diminishing real growth. That promise hasn't even come close to being kept.

I am embarrassed that the United States did not have an unmanned mission for Halley's Comet. I just can't believe that we couldn't do that. And when I look at the budget cutbacks that have been made and the lack of understanding of our commitment to space, only seven-tenths of 1 percent of our entirely national budget is devoted to NASA, only four-tenths of 1 percent to space travel or space exploration, either ELV's or manned spacecraft, a rather puny effort compared to the benefits that have come back.

I am amazed at the lack of understanding and the number of times I am asked the question in my capacity as chairman of this subcommittee of why we waste money in space when we have so many pressing needs here on Earth. My first rather flip answer is that we don't waste any money in space at all. I did not take credit cards or a wallet with me into space, no cash. There aren't any stores out there; there is nothing to buy. So no money has ever been spent in space. It is spent in virtually every State in this country. Everybody contributes in one way or another in tens of thousands of jobs in the aerospace industry across the Nation.

So we haven't wasted money in space. It is interesting to me that even having been around the committees, the authorizing committee and the Appropriations Committee for so many years, I don't suppose that I even realized, reviewing annual budgets, what the spinoffs were from space or the potential until I had the opportunity to train as a payload specialist and to fly in space.

NEED TO EDUCATE PUBLIC

So I don't know how we do that job. That is the purpose of these hearings, to try and look to the future to get us back on track to recover from the Challenger accident. But more importantly, we need to somehow find out how to educate the American people much better than we have in the past. They use products and services every day that they take for granted and have no recognition whatsoever that they came from space research and development. I suppose that came forcibly to my mind as Charlie and I sat in Earth observation lectures. I learned more about geology and oceanography and vulcanology than I had ever heard of before, being a business and finance major in college.

I don't know how we get that message across, but we need to, and we need to get it across here in Congress. I am amazed at the large number of my colleagues who support NASA. They support it overwhelmingly. But still, there is a lack of understanding of the returns that we have gained in benefits and the dollars that were received back. The lowest estimates are $7 or $8 in the private sector for every $1 of taxpayers' money. Most people also don't understand the aviation side of NASA, from supercritical wings to high-bypass engines, all sorts of things that commercial jets, 757's, or 767's are using today; crash safety research that they do; all sorts of Earthbound things that have nothing to do with space but improve our aviation safety and capabilities in normal types of aircraft.

So I express that frustration and can only say that we need to try to continue to do a better job. I am even amazed sometimes when people were watching Wimbledon last summer and don't really understand why in the world they can watch it live, that it is a satellite up there that is bringing those pictures to them in real time. Or the navigation improvements, when I look back at learning to navigate with low frequency radio stations and manual direction finding.

That hasn't been too long ago, 30, 35 years ago when I had to learn Morse code, the dots and the binary codes and the code of silence and that sort of thing. If you can put an AIRNAV into a Piper Pacer with 15 white points and so on and a course on autopilot. Who ever heard of autopilot when I first started to fly? They were not in very many aircraft. So the explosion of technology is rather remarkable.

We don't seem to do a very good job of communicating that to the American people. Despite that, the support is overwhelming; 73, 75 percent in most polls think what it would be if they really knew how many things they were using every day that benefit and improve their lives here on Earth.

I also think, Joe, of what you said, and Charlie, I am sure, remembers this as well. In one of our first appearances as crew after we got back from STS 51–D, someone asked Karol "Bo" Bobko, our commander, what would be the first planet that we would explore from space, and Bo just so quickly, like "Why don't you know?" said, "The Earth, of course."

That is another thing that I don't think people really realize, forgetting the specifics spinoffs. They don't really understand that we are learning far more about our own planet from space than we can ever learn here on the surface of it. Space exploration, before we ever walk on the surface of Mars, we will learn far more about our own planet. So I appreciate the willingness of each of you to be here today and to talk about your view of the future and ask you to continue that effort.

COMMERCIALIZATION OF SPACE

There is another great lack of understanding, too, of the commercialization of space that has already taken place. I am asked that question all the time, "When are we going to get away from just government and commercialize it?" They don't realize most of the satellites up there are commercial, for-profit satellites now. Most of them have no idea that Charlie Walker has been on three shuttle flights and processing some fluid in a commercial electrophoresis effort. I have said this many times, I might as well say it for the record, that I spent 7 days, 168 hours, in space trying to get Charlie to tell me what was inside that machine, and he would not do so. I still don't know what it is intended for, and it is really unfortunate we don't have more people in Washington like Charlie who can keep their mouth shut. [Laughter.]

I even stayed awake some nights hoping he would talk in his sleep and I could find out what that material was inside. But he didn't.

Mr. Hood, he didn't give it away at all. I have no idea of what particular cure to which disease you are working on.

But I would make one more comment on that, as well. When we talk about the dollar spinoffs from space and we talk in terms of technological achievements, all we can improve is our standard of life here. The day will come that we do cure a major disease because of being able to process pharmaceuticals in space, and there is no doubt in my mind, it isn't a question of if, it is when. That will take place.

How do you place a price tag on that when people argue about whether we could have, should have manned space flight or not? You can't place a price tag on that kind of a benefit which will occur; it absolutely will. Then you are talking about tens of thousands of lives. I have never been able to place a value on an individual human life, let alone tens of thousands of them. So I hope we are able to communicate what space can do for us in the future and focus on that; find out what happened with Challenger; fix it, and get on with the future.

DESIGN OF FUTURE SATELLITES

Let me ask you some specific questions. Joe, having been involved in the first space salvage mission on STS 51–A, do you think the capability to repair in orbit or return satellites to Earth and make modifications will change the design of our future satellites?

Mr. ALLEN. Mr. Chairman, that is a very specific question, a little difficult to know what the proper answer should be. I should say that some of the first repair in space was actually done by my colleague at the table, Pete Conrad, who did a major repair job on Skylab many years before this rather minor salvage operation was attempted.

Senator GARN. Yours was more spectacular and got more attention, however. Pete has to be secure in that. [Laughter.]

Mr. ALLEN. Pete's was a home repair job, I think. In my case, I do genuinely believe that one thing that we have learned over the 20 years, and it astounds me how easily we forget this, that space, in many ways, is like Earth. There are some differences, but the preponderance of the evidence is that people can work in space exactly as people work here on the surface of the Earth, as ably or, for that matter, sometimes as clumsily.

Senator GARN. But with a lot more fun.

Mr. Allen. But a lot more fun, and there is very little reason to go to extreme design philosophies to distinguish between working in space and working on the surface of the Earth. You have to take a few special measures for space work, but not many. The things that we take to space, we should ask ourselves, were we on Earth, should we build this to be maintainable and repairable?

If the answer is yes, then we should make it maintainable and repairable in space. Oftentimes on Earth, it does not make sense to make something reparable. Most items around our house we make reparable. A few we don't, for example, pipes that we put under foundations; sometimes we do not build those foundations in order to be able to repair the pipes.

A few times, I can remember, we wished we had made another decision with regard to both the pipes in the ground and the equipment in space in wishing we had made them to be repairable.

The industrial space facility I am working on right now is being designed it to be fully repairable and maintainable. There is not one part of it, save possibly for just its hull itself, that we have not designed to be fixed by people right there, as we would fix something on the ground.

Senator GARN. Charlie, as you mentioned and I have mentioned, I was fortunate enough to have the opportunity to see for myself the electrophoresis manufacturing process aboard Discovery, although again, not knowing exactly what it was doing. The only thing I didn't like about it was for those of you who don't know, when you have the electrophoresis aboard, it replaces your galley, and you have to have food warmers, which greatly lengthens the food preparation time and so on, but it was worth it, despite the fact you stole our galley from us.

COMMERCIAL MANUFACTURING IN SPACE

What steps do you feel, beyond what we have already done, we need to take in the next 5 years so that we really develop a climate for a vigorous commercial space manufacturing program?

Mr. WALKER. Well, Senator, that is certainly an appropriate question. First of all, I think maybe before I endeavor to answer that, I will apologize for the lateness of your meals on board the flight. It was more like a camping-out trip in that regard than it was a luxury flight, certainly.

I might also say that I will be less close-lipped today than I was on board that flight. In answer to your question, I think there are some basic things, two points come to mind, with regard to what might be done to make for a more vigorous future in commercial manufacturing in space.

There is a basic one, recognizing that this world that we live in and the world's economies are competitive and that we in this country have always, certainly in the past many generations, led the Free World's economies into new markets and to utilize technology for everyone's benefit, and we should continue to do that. We should not lose sight of that basic necessity.

In that, I am saying, of course, that we should do what is necessary to make for a vigorous commercial move to utilize space. I think also that there is in that the necessity, as I mentioned in my testimony, for consistency in Government policies and support for our Government space program, and you, yourself, have restated that.

I think, specifically, that NASA's Commercial Space Programs Office provides excellent support in that area within NASA and that that Office should continue to be supported and given strong support to continue its efforts. I think that there should be continued and more active relationships between Government and industry, particularly small businesses and nonaerospace industry, because we are certainly going to have to see the nonaerospace segment of our economy involved in utilizing basic resources that are in space, that are now available to us.

For all commercial activities, I think that I just might mention that we need to be farsighted enough to shape our fiscal and financial structures such that they don't bias or prejudice businesses against moving into space, such as limiting them by undue taxation or the inability to accelerate depreciations or space-based resources; that we should consider space as just like ground based and not different.

Those are, I think, a few things that come to mind, and I am sure that there are many others. But there are some basic things, and one of those is educating ourselves that it is a real future; we can't ignore it and just let it come about on its own because it won't.

MANNED VERSUS UNMANNED SPACE FLIGHT

Senator GARN. I have been to a lot of debates over the last few weeks over manned versus unmanned space flight. Do you feel that it is necessary for men and women to be in space to further the processing of materials?

Mr. WALKER. Well, I personally have no doubt of that, Senator. Yes, indeed, men and women are necessary in space to bring about this commercial future. I would estimate that of my time on board the shuttle, I spent 10 percent of it, 10 percent of my waking hours, certainly, performing repairs, and two other gentlemen at this table have alluded to major and significant repairs of recovery operations in their cases, external to the crew compartment and the shirt-sleeve environment that we occupy.

But on my own small scale, I spent a lot of hours repairing, making repairs, vital repairs to my commercial, experimental, and development equipment. That kind of thing will continue. Equipment is imperfect and does need to be repaired. I probably spent 50 percent of my time, on top of that repair time, just tweaking and perfecting the process, which was my real intent and reason for being there.

When you do development work, you need to follow along with that developing, maturing equipment and provide the best tools to work on it when it is not performing to the best efficiencies or failing. As you well know, the best tools the worker can take with him are his own brain and two hands.

Senator GARN. I would agree with you completely. That is why I am puzzled by some of the very experienced Ph.D.'s and so on who think you can do it all with ELV's. I certainly had the opportunity to observe you tweaking and fixing and getting the process going and changing while we were depressurizing for the EVA and dealing with all of the other functions of the orbiter. Without you there to tend it, it certainly would not have functioned properly.

Senator Lautenberg?

EXPRESSION OF APPRECIATION BY SENATOR LAUTENBERG

Senator LAUTENBERG. Thank you, Mr. Chairman.

I, too, appreciate your appearing here today, each of you, particularly those of you who have been in space, have made lasting contributions to our country and our world. I want to say personally, thank you, for not only the daring, but the knowledge and the experience that you brought to it and the message you brought back.

Senator GARN. Senator Lautenberg was in favor of my going. I haven't yet found out whether he wanted me to come back or not. [Laughter.]

Senator LAUTENBERG. Your temperament got better, Mr. Chairman, after that trip in space. I don't know what they did to you [laughter] but I wasn't able to do it, I guess.

But no, we were glad to see you, Jake, come back and in good health, and many of us, despite the ribbing here occasionally, were very much interested, if you remember, in your experiences as you related them to us in one of the rooms here. It was very interesting and very helpful to gain some insight, and I don't want to rain on the parade.

My experience is different, different from any of the people here. I come from business. I ran a pretty good-sized corporation, a very successful corporation, and one of the tasks that I always had put to me was to do as much as we can with as little as we had. Spending lots of money was never a measure of success in the business world, as all of you know, and I am not, by raising this, suggesting that that is your mission.

RETURN ON MONETARY INVESTMENT

But I do want to say that as I look at what we have spent in space over the years, certainly, the American people are committed to space exploration. Despite the fact that at times we haven't really—and that applied to me as well as lots of people that I talk to—really fully understand the full implications yet of what space can do for us as human beings and creating a better world with better health, things that we discover, the American people are responsive. They are also curious.

They want to know what we got for our money. They want to know that we used the resource wisely. When I look at what we have spent in space since 1965, it is true that the level of spending has gone down. It has also shifted, by way of interest, to more being spent by DOD than by NASA as contrasted to the middle sixties period when the ratios were quite different, almost twice as much spent by NASA than DOD. Now we find ourselves in just the reverse condition, which, frankly, I am not happy to see.

But we did spend, by my rough calculation, in the period of time from 1965 to 1985, inclusive, $120 billion in space and research and launch vehicles, et cetera, not, certainly, an insignificant sum by any yardstick, regardless of the wealth and the resources of this Nation.

Mr. Walker, you said something; I think you referred to brains and two hands.

But I do want to make the observation that whatever we learn in space or through science, with all the value that it can produce, can never, never equal the value that can be produced by continuing to educate and to enhance the talent and the ability of our young people off into the future. And unfortunately, we are made to make decisions between what we finance and what we don't finance, and very often, one program is at the cost of another.

I am not asking you to do the budget for the United States right now, but it is a problem that we here are wrestling with on a constant basis, and we can't—as much as we would like—spend all that we would like on space exploration programs and meet other demands in our society that also require funding. I mentioned education because all of you will be sensitive to that.

COMMUNICATIONS SATELLITE INDUSTRY

I would like to talk, if I might, about the communications satellite industry. With all the talk about the commercialization of space, is it fair to say that the communications satellite industry is really the largest private industry spawned by NASA? It is, if not the largest, the most obvious, certainly. Is there any challenge to that?

[No response.]

Senator LAUTENBERG. Shipments of satellites alone topped $2 billion last year. The Earth station industry accounted for another $1.2 billion. Has NASA's contribution to the commercial satellite industry been a success in your judgment?

Mr. HOOD. Yes.

Mr. WALKER. I think the basic technology that allows the satellites to perform in orbit wouldn't be there now if it weren't for NASA's investments 20 years ago.

Senator LAUTENBERG. I agree. Could the private sector have done it all without NASA, without the money invested by our Government? Not likely, right?

IMPACT ON U.S. EMPLOYMENT AND INDUSTRIAL COMPETITIVENESS

What has been the impact of the satellite industry on the U.S. employment and industrial competitiveness in communications and productivity? Is it fairly significant, would you say?

Mr. WALKER. Yes.

Senator LAUTENBERG. Have the Europeans and the Japanese now targeted this area for their own development on their own?

Mr. CONRAD. Yes.

Senator LAUTENBERG. The French have sold a domestic communications satellite to Arabsat. We don't have a monopoly anymore; I wish we had. I wish we had it by virtue of our ability to compete in the marketplace, and I wish that we had the cheapest, most efficient system to be used, the most efficient launch vehicle. The French and Italians say they want to compete with the United States in commercial satellites just as Ariane competes in launch services. You would agree with those observations, I assume.

So with all of that, I have a problem, very frankly, and I have got to ask you whether it makes sense for the administration to propose to kill the only major communications satellite technology program. Do you think that makes sense, after the investments have been made in the face of the competition that we face from abroad, to cut back on investing in this program? Should we go forward with it? Should we continue to invest in communications satellite technology?

Mr. HARR. May I take that on a little bit, Senator Lautenberg?

Senator LAUTENBERG. Depends on what your conclusion is going to be. [Laughter.]

Mr. HARR. If I understand the thrust of what you are driving at, it seems to me it relates to the basic point of the engine function in the total economy, which includes communications satellites, which includes everything else that we are competing with the rest of the world on. The engine is provided by the space effort, broadly.

Senator LAUTENBERG. Pull that microphone a little closer, will you, please?

Mr. HARR. A little history is not bad here, I guess. Since World War II, we were the one western industrialized nation that wasn't devastated by war. Of course, the Japanese were, also. We were the ones who got the head start in high technology in the post-World War II period, partly because we weren't devastated, partly because of defense, mostly because of space in terms of deep strides.

In the eyes of our European competitors, the degree to which that gave us a leg-up was enormous in terms of forced inventing of new technologies, and so forth, and having permeated American industry. They wanted to catch up, and their economies did restore themselves and they did catch up because it is so attractive to be competitive, so favorable to be in the competitive position in these high-tech areas, which is one of the biggest fights in international trade these days.

The partnerships that have evolved here and in Europe and in Japan between industry and government have varied in form. They have a much more unified operation between government and industry than we have here. But of course, we have gotten essential and vital, without which we could not have done the basic input by our government through NASA.

Senator LAUTENBERG. Dr. Harr, I wanted to focus on this fairly narrow area. I had a specific purpose there, and I wanted to point out what I think is the folly of the decision being made here, and that is, to continue to pursue the program in general while we lop off some specifics that have been very meaningful to us that have direct commercial payoff.

When we look, particularly at the communications satellite technology, it concerns me that the recommendation is that we eliminate that program from our NASA budget, and that is the point I wanted to make. I haven't heard any disagreement, unless you are going to disagree with that.

Mr. HARR. Senator, I am afraid you will never find me disagreeing with retaining any part of the space budget.

APPLIED RESEARCH AT NASA

Senator LAUTENBERG. OK. Then let me go on to a couple of things, if I might. The commercial benefits of NASA's spending comes from applied research, and I don't mean to downplay the importance of basic research. I support that, but the jobs on the ground today in the private industries and computing and semiconducting and systems integration, et cetera, were developed, of course, by applied research at NASA; is that correct? The more immediate benefits have come not from what we learned when we got to the Moon, forgive the challenge here, but rather what we learned in getting there. Is that fair to say? So this isn't necessarily an academic distinction.

The administration proposes, as we have talked, to end NASA funding of satellite development.

My assistant says that if you would be more vocal in your response, we would at least know for the record. I don't think she is recording nods or no nods, if you don't mind. It is an important point.

SATELLITE DEVELOPMENT FUNDING IMPERILED

The administration proposes to end NASA funding of satellite development. It proposes to abrogate support of Landsat commercialization. It will spend less than $20 billion on direct support of space commercialization, a little over $10 million on technology utilization. While we spend more on space than Europe or Japan, we spend a smaller portion of our space budget on applications.

Are we blinded by philosophy or an ideology here? Is there something within our planning that any of you sense that directs us away from the specific and into the more general?

Please.

Mr. CONRAD. I would like to address that and really go back to your first question. I think one of the most difficult things that the Congress and the Senate has to deal with on those kinds of budget items when you are in research and development programs and you are pushing the future is for anybody to give you a good number that they can absolutely swear by, because we don't know where we are going. Our part of that program is proving that we can do that as we develop it.

I can understand budgeting in housing or its own place, where you can make a concrete judgment and get a job done. That is No. 1.

From the industry side, he, too, is interested in spending the least amount of money to develop his strategies for whatever it is that he is going to do in the future, and the smartest guy does get the job done with the least dollar and produces that product or advances a line.

One of the things that goes specifically to communications industry—and I, by no means, am an expert on that, but you are facing a frequent amount of Government subsidy from the other side. The fact that the French satellite can go up, Ariane, is charging a number that there is no way in the free enterprise system they are making a dollar; it is being subsidized by the French taxpayers and the rest of the European countries that are putting money into that program because it is government money, and if we went out right now to launch a new communications satellite with a commercial Delta launch vehicle, no matter how hard we shape it, it will cost probably in the order of twice as much as you can get a ride on Ariane because of their subsidy.

How you take all of those things, and the first one is the toughest nut? To be quite honest with you, it is my personal opinion that underlying way back what happened on the Challenger accident is the fact that that program never was budgeted correctly to get a solid string to get that job done and know it was absolutely going to be safe. I think Senator Garn, who sat on that committee, is probably more aware of the funding that went on in that and is aware that is what drove it out from 1978 to 1981.

I am going to guess, and I am speaking as a citizen, and I have no knowledge of NASA's budgeting process, but if they drop that satellite, it is probably in trying to find the dollars in their best estimate in that budget to get another job done which has probably, in their opinion, a higher priority only because it may be the station itself or the Shuttle operations to get into existing things that need to be done first.

Senator LAUTENBERG. Not to extend you, but would you allow me to interpret your remarks and say everything was perfectly managed and that all the funds that we put in there were precisely monitored? There are people who would disagree with you, and I hesitate to do this, because I so much respect your experience and the knowledge that you have.

Mr. CONRAD. I do not have personal knowledge.

Senator LAUTENBERG. I would have to tell you this, there are those who say that some of the program wasn't managed quite as efficiently as it might have been, and therefore, would challenge your conclusion that says that there wasn't enough budget money to do this job properly. Rather, the money that was available wasn't managed as carefully as it might have been. I, personally, do not have specifics to debate with you the efficiency of the program. I don't want to do that.

Overhanging us is the loss of lives that saddens us all; we think that we tried our best. I certainly hope so at all times, to protect those folks.

But things happen. The question is in the scheduling of the launches. Lots of factors come into this, and I think to take the single conclusion out that says that we didn't put enough money in to carry on properly, I think deserves a fuller debate than we are having.

Senator GARN. I think Pete would have answered that, of course, nobody is saying that it couldn't have been done more efficiently. I will guarantee you in hindsight that you could probably look back at your business and say that there are things you could have done differently that would have maximized efficiency. Certainly, NASA has made mistakes.

PROCUREMENT WASTE AT NASA

One of the areas that I discovered that I still don't know how to handle is procurement. There is a lot of waste in procurement at NASA and in every department of the Federal Government because of the rules and regulations we have imposed. The paperwork burden is enormous. It is just incredible what you have to do to requisition something that has nothing to do with flight safety. NASA would like to get out from under that burden. We come back here. I have tried to find a way of why you have $600 toilet seats in the military and why you have incredible waste in housing.

I can show you housing projects that cost $50,000 more a unit than it could have been if we had just gone out with private bids and all of that. It is a governmentwide problem, and I would be the first to say that NASA, for a number of reasons, could have done better with their money.

But I would still agree with Pete. As you look back over those budgets, forgetting the efficiency of a particular program, programs that simply were not funded, just simply said, "No, NASA, you are not going to be able to do them," there is no way you could squeeze enough out if you were 99 percent efficient to do certain programs that Congress has not allowed them to move forward with, like the Halley's Comet thing. No matter how efficient you were, NASA wanted to do that. Congress simply made a decision, "We are not going to do it."

So I think there is enough.

Senator LAUTENBERG. Aren't we fortunate that neither one of us are lawyers, and, therefore, I, speaking for myself, don't know how to conduct a courtroom inquiry. But I think we have to let the witness furnish his own answer without coloration from the defense attorney or the plaintiff or whatever.

Senator GARN. I am not trying to color his answers. I was answering your question, and he is certainly capable of answering it for himself.

Why don't we give him the opportunity to answer?

Senator LAUTENBERG. I think I did. I made an observation, and I am happy to have Mr. Conrad's response to it. That is why he is here. I am also here to ask the questions, and I intend to do it.

Yes?

DIFFICULTY WITH PROGRAM

Mr. CONRAD. I am not an expert on how NASA spent that money over time, but when I was in NASA in 1973, it became very apparent to me that the mood and the way things were going was going to be a very difficult program to survive and manage. Quite honestly, it was one of the reasons I left, because it was apparent to me I couldn't fly for quite a few years. I said, in 1978 at that time, my personal opinion was it wouldn't fly until 1980, and I was wrong by a year; it didn't fly until 1981.

The thing that I did want to stress, not to get over on the NASA budget and R&D, but I think it is a difficult problem for the Congress and the Senate to make judgmental values when you are dealing in those kinds of dollars for a purpose. This is jerry-rigged. The thing that I did want to point out is what we face overseas and what will affect us here, because we are trying to operate in the free enterprise system, is this Government subsidy.

I spent 8 years with Douglas Aircraft Co. battling Air Bus Industries, which was a subsidized industry, and we were having to sell those airplanes under the free enterprise system, and we were having a terrible time. Not only did the subsidies come directly to the airplanes, but the financing came from the French Government and places like that. So we had a tough road to hoe there. You are facing the same thing in the communications industry when you have the subsidized launch vehicles, and I would bet that some of that French communications satellite comes from subsidized business.

Senator LAUTENBERG. I wouldn't argue the other side of that, because we see it in trade issues constantly. The fact is that we often operate with some disadvantage.

On the other hand, again, as I pointed out earlier, we have spent a substantial sum of money in getting our program to where we are, over $120 billion, not an insignificant sum, and the creative genius that our country has has been invested here.

I am not sure, by the way, that people in the business world, are making the best decisions on a competitive basis. I see America losing out in terms of the quality of product, the price of product, having little to do with foreign subsidy. It is a question of how aggressive we are about managing our funds and managing our resources.

QUESTION OF MANNED VERSUS UNMANNED

Let me get on to one other thing, and I will be finished with my questions. The question about manned and unmanned is, I guess, going to be debated for some time. If there was a unanimity of opinion, it would be easy to deal with, but there isn't. People like yourself, experts, have certainly differing degrees of confidence in manned versus unmanned. I haven't heard anybody in a responsible position of the Government say we should cut out our space program. I haven't heard anybody who will say that we should abandon manned flight.

Certainly, I think, it is appropriate for us as representatives of the people in this country to ask the questions whether manned flight is the only way to do certain things.

I respect and I listened very carefully to what each of you said about fixing things; about directing things; about making the decisions that, thank goodness, still only a human mind can make. I don't know whether the hands are quite as good as a robot's hands at times.

But can we accomplish more things than we have with unmanned flights? All of us were impressed, and I assume you as well as this neophyte, with the observations around Uranus and the Halley's Comet project, They were fairly impressive. It tells you that there is still a lot that can be accomplished by unmanned flight. You agree with that, I assume?

Mr. ALLEN. Senator, if I could jump in here, I certainly do agree with that. Indeed, I said earlier that in many ways, there is very little difference between space and Earth, and you referred to your time as making business decisions. I would suspect the decisions you made were not couched in manned versus unmanned. You thought in terms of what is the job and what will it cost, and you made a decision based on the most efficient way to do it.

The arguments were not man versus unmanned, but in many ways they were. Do we do this automatically, or is it better to keep people involved? Those very same decisions must be made for every space endeavor that we set out to do, and it should be in those terms. What is the best way to do it?

There is an argument weighed against the space station, and one that is suggested by a very learned scientist, James Van Allen, who says machines do things better than people. The scientist is exactly correct in saying that the machines count nuclear flashes better than people do. We quit doing that in our Earth laboratories 30 years ago, using people to do that. Machines do that much better. And many factors that are being contemplated by leaders in business right today, as they look to the future, will involve more machines and fewer people. But people always will play an important role, I am convinced.

SIMILARITIES OF EARTH AND SPACE

That role changes, and we must look at how that role is changing, but remember that there is not much difference between Earth and space in that regard. There may come a time when there is no longer a need for people in space. I personally believe that that will happen on the very same day that there is no longer a need for people on the surface of the Earth, whereupon we can all go on vacation. And I, for one, would like to go to space to spend my vacation.

Senator LAUTENBERG. I hope that the observation, Dr. Allen, isn't an accurate one, because I think it is possible that man's habitat was created somewhat differently by powers different than ours. The most obvious use of unmanned research instruments is undersea. When you look at the recapture of parts of the shuttle, the discovery of sunken ships and things, it is quite incredible that so much of this is done without a person involved.

As a matter of fact, while we were limited by man's capacity to endure, we were very much curtailed in our ability to explore. Things have changed. Again, I want it very clearly understood: I respect, admire, and salute the accomplishments of our space agency and the industries around them, I really do. I think it has made the kind of contribution that will last way beyond our being here today, beyond our lives in this world.

I would say to you this: that as we examine these questions, that you as well as I have to look at the alternatives and look at the way we do these things. It is not enough, in my view, to say: Let's just continue to fund these things at the maximum limit that we can digest, but rather, how well do we digest it, and that is our mission' What I tried to do today is point out in a couple of very specific areas where the benefits are obvious, current, and that we ought not to abandon those casually without recognizing that we lose a distinct advantage in terms of economics, competition et cetera.

I thank you, Mr. Chairman.

Senator GARN. Thank you, Senator.

DIFFERENCES IN UNITED STATES AND RUSSIAN SPACE PROGRAMS

Mr. Conrad, based on your familiarity with the Soviet space program, why do you think they bypassed the space shuttle concept and went directly to a space station?

Mr. CONRAD. Historically, even if you go back to Russian aircraft, they are very good at using what they have that works, and if I might shift back to our program for just a second to review the history, we made a conscious decision in 1972 to go to a manned reusable transportation system and started the shuttle program.

In order to do that, we gave up any more flights. We flew our last flight actually in July 1975 which was the Apollo-Soyuz mission. That was the last time we flew, and we didn't fly again until 1981.

But those flights that were probably two Skylab flights in Apollo-Soyuz, they were already scheduled and funded, and they were going to fly. At that point in time, the Russians started to develop a extended capability with their Soyuz space station. When it had what their then current—which they are still using to this day—expendable launch vehicles that have changed very little over that time frame and they went into developing unmanned rendezvous and resupply and unmanned return from the space station at the same time they were putting man up there and letting him extend his period of time in space until they ultimately built up to what I mentioned in my testimony, a 234-day flight, manned.

It appears to us to this day that at some point in time, not too long after that, they have, in fact, started on a vehicle—I don't know whether it is reusable—but it appears to be a vehicle that will land like the shuttle, similarly will land on a runway, and then we have seen scales of this vehicle recovered in the Pacific by the recovery ships.

So I think it is quite obvious that we know they are working on that program, and it appears to me that having not run into a major technical problem, they should probably be getting ready to fly a vehicle similar to our shuttle in the not too distant future. So they kept flying, they kept a continuity. They used their old launch vehicles. They now apparently have an upgraded launch vehicle which they put this portion of the station up with, but we do know that they are working on what appears to be a manned reentry vehicle.

BALANCE NECESSARY IN MANNED VERSUS UNMANNED

Senator GARN. What Senator Lautenberg was just talking about I don't disagree with. I don't want to be misunderstood in my questions about the value of manned space flight. I believe we need a balance; where the argument comes is over what that balance is. That is why we worked out an agreement last year with DOD to fly 8 shuttle missions a year but also to produce 10 Titans for CELV's. Maybe that balance, in light of the Challenger action, that needs to be tipped more the other way. I don't know. I just want to make that point.

I am sorry he has left. I don't disagree with him. I think Joe explained it about as well as possible that you ought not to make that decision on the basis of just formulas or *x* number of dollars here and there, but which can best do the job. There is no doubt in my mind, there are some functions that an unmanned vehicle can do better, and other things, like what Charlie is doing, require a human being to be there. That is how I think we ought to achieve that balance. I don't want to see it become paralyzed.

The Senator is correct. There are very few—I don't know anyone in Government who thinks we ought to stop manned space flight. There are simply some professor types out there who think that we should.

As some of you may remember, last year, I held up a lot of NASA's money on their study of the Space Station because I thought they were going too far in the direction of the fully manned station, and I had to push the frontiers of robotics. Jim Beggs of NASA was not very happy with the trouble I gave them on that. I said: Do another study and find out where that balance is.

I happen to think it is too much in the manned area at this time, and if we are going to have a successful space station, we need one that will do both. I want to make that very clear, that deciding on where the exact balance points should be is the most difficult part of it. But I don't think there is a great deal of difference of opinion. Most people think we do need both.

Joe, you outlined it better than I have heard it described before. So I thank you for that particular answer.

REPLACEMENT ORBITER NEEDED

Pete, in trying to look at this balance, however, looking at the orbiter fleet size and the frequency of flight that is critical to the rate of commercial space development, do you feel we need a fourth orbiter, a replacement?

Mr. CONRAD. Absolutely. Let me qualify that. That is a manned system. Currently, we have, with the space station, is a system that is an integral part of or an extension of the space transportation system, and the current space station configuration is designed to be operational with a STS vehicle, an orbiter. We certainly could stop and take a look at using ELV's to go to the space station.

Now, if you say I just need to use ELV's to take other manifests, you can do that, also. But with respect to the station and the current manifest the way you look at it, you need a fourth orbiter. I think, and again, I don't know solid numbers, but I have an intuitive feel that to change the system so that the station would be compatible with both an orbiter to take the man up and bring them down and any superlarge thing and putting ELV together out of existing ELV's, but add that capability to reenter and then add that capability of that ELV to return an unmanned payload, I think a fourth orbiter would come out somewhere in the same ball park as far as the amount of dollars it would take to do this.

It would also require some rethinking of how you would actually configure the station. On the side of using the orbiter only for the Station, and using the ELV's to put up other payloads that can be carried on those ELV's as opposed to the orbiter, you run right smack into the problem: The bulk of those are commercial and here we are running against subsidized ELV's in other countries. I think we would wind up having to subsidize to get a commercial payload; the Government, somehow it would have to be subsidized. Otherwise, they are all going to go on the other vehicles.

Senator GARN. Mr. Hood, based on your corporate work in commercialization, how do you think we should compete? There are some who, all along, have pushed for full pricing of satellites. All that would have done would be deliver all the satellite business to Ariane, and I have always felt that whatever we could charge for was an offset to the cost of the shuttle. Certainly, it was better than getting nothing out of it.

PREDATORY FINANCING

But we have mentioned the competition with Boeing. As Chairman of the Senate Banking Committee, I have dealt with predatory financing beyond the issue of subsidizing, just the construction of the R&D and all of that. France has been notorious for dumping on us when prime rates were way high; gee, you get 9 percent when prime is 21, things like that. It is utterly ridiculous with predatory financing. People would say: Gee, I don't really want to buy the Air Bus, but look at the deal I am getting.

PROBLEM OF SUBSIDIZING

So in the future, looking at the commercial side of it, how do you compete with governments who are willing to overtly subsidize their products in their country? How do we solve that problem?

Mr. HOOD. The answer to that question is not an easy one. As a matter of fact, we don't have an answer to it, and that was the reason we chose not to commercialize the Delta launch vehicle. As you know, we did commercialize the payload assist module two generations of that.

The PAM Program has been reasonably successful as a commercial venture, because with NASA, we could develop a package with financing, and an attractive cost, to compete in that international market against Ariane. Particularly because with the shuttle, we also provide an opportunity to fly payload specialists from time to time, and there was a certain attractiveness about the shuttle that Ariane could not create with an expendable vehicle.

But we have not found the answer on how to compete in expendables without some agreement with the Government whereby they would buy the vehicle and they would, in some way, subsidize it the same way that the Europeans are doing. We are going to fall far short of making that a sound business prospect.

Senator GARN. I guess you wouldn't want Charlie to ride in an ELV and come back in hanging on to the electrophoresis experiment on a parachute.

Mr. HOOD. No; I don't think I would, sir.

NASA OFFICE OF SPACE COMMERCIALIZATION

Senator GARN. Mr. Hood, do you feel that the NASA Office of Space Commercialization is doing all it can to be helpful in this area?

Mr. HOOD. We have found them very cooperative in our dealings in our 7 or 8 years with them. I would be personally more gratified if that office had more visibility in the overall NASA organization, in other words, reported to a higher level in NASA.

I think one of its problems is not with NASA itself, but the executive branch of government not coming up with some consistent policy to support it more than the NASA operation might be.

NASA BUDGET REVIEWED

Senator GARN. Gentlemen, we may have some additional questions for you for your response in writing. I do appreciate you being here, and if I could back up just a little bit so that the record is clear—and I am sorry Senator Lautenberg is not here—but I would not disagree with him that $120 billion is not an insignificant amount of money. That is a lot of money in Utah. I am sure it is in Missouri and Texas and other places.

I think you have to consider that the amount of money spent over those years averaged about $7 billion per year. I was not attempting to indicate that I felt that it was an insignificant amount of money. No; it has been a large amount of money, but I think you have to put it in perspective, that of the average cost per year.

Congress does have to make difficult choices, more difficult than we ever have before since I have been here with the $2 trillion deficit. So NASA is not going to get all it would like or need; there is no doubt about that. But when we impose budget ceilings, it isn't a matter of giving them everything they want. I don't want to leave that hanging. NASA hasn't even come close. Every year in this subcommittee, I have examined what NASA's request to OMB has been, what OMB as done to it, and then what Congress has done to it after that.

After struggling to get NASA just a little bit above the freeze level for fiscal year 1986, now the automatic sequestering took another $300 million out of it. I would share Senator Lautenberg's concern for not doing away with a program that he is in favor of. When we do that to NASA, then they have to make tough choices as well. They may not make them exactly the same way that you or I or Senator Lautenberg would in making those value judgments. Nevertheless, NASA doesn't want to discontinue that program, either. I will guarantee you. That is OMB.

So we do have a difficult budget process. NASA is not perfect or totally efficient. I look back at the private sector with the results of the recession in 1982, as long as times were good, how easy it was to pay whatever wage rates the unions wanted in the airline business, the automobile business. "Let's not fight with them, let's argue. Let's have 150 corporate vice presidents" and so on. It is amazing to me the positive results of that recession and how business has done a lot of trimming, as well, and are operating a lot more efficiently.

So NASA is not lacking in blame. There is waste and inefficiency that goes on, no doubt about it. I just try to make the point that in the perspective of the total budget, that the absolute dollars are large, but in terms of four-tenths of 1 percent of the total national budget, that is not a very large effort for space or when you consider the returns. There are a lot of other programs that there is virtually no return at all in Government expenditures.

LACK OF EDUCATION NEEDS TO BE ADDRESSED

So I am hopeful that we can do a better job of educating the American people and Congress as to what the benefits are, and if they still choose to say we can't afford that, that is a different argument. But I think a lot of the judgments have been made on not understanding what we have gotten from space in the past or the potential or to the future. When you have that information available and my colleagues in the Congress wish to make a value judgment that we can't afford this, and something else is more important, that is the way the process works.

I just don't want our future shortchanged because of lack of understanding without all of the facts available so that people know what they are buying. We all do that, whether we are out buying an automobile. You look at the extras and accessories on it and decide whether you can afford power steering and power door locks and the sun roof, and maybe you can and maybe you can't. We all have to make those value judgments within our budget.

I hope some way, some time, to figure out how to handle the procurement problem, not only for NASA. There has got to be a happy medium between the old days when you could have a lot of fraud and graft and Government spending and why we tightened down so and all these forms to prevent that type of abuse to the point where you create more waste and inefficiency with all the rules and regulations than you save if somebody was stealing from you. There has got to be some way in between. I have not found it yet.

I can tell you some stories about items that were not flight safety but still go through the same process because Congress either requires it or a Government agency is so afraid of getting caught they are covering their behinds with paper. So that whatever happens, they should know we did it properly, no matter how much that toilet seat cost.

HELP SOUGHT IN PROCUREMENT AREA

So any of you have any suggestions on procurement and how we can improve that, I don't mean right now, but we would appreciate help in that area, because as long as we are dealing with the budgetary problems we have overall in this country right now, it is incumbent upon us to do everything we can to maximize the efficient use of the dollars we have. If we are going to be limited in the area of $7.5, $7.6, $7.7 billion a year, then the Senator is absolutely correct: It becomes all the more important to use those dollars wisely so that you can keep this program going or that program. So we have got a real challenge ahead of us and in a lot of areas.

I certainly appreciate your willingness to be here today. You have been very helpful to the committee, and we look forward to having you back in the future.

Thank you very much.

Mr. Walker. Thank you, sir.

SUBCOMMITTEE RECESS

Senator GARN. The subcommittee will stand in recess until this afternoon at 2 p.m. in this room where we will continue to hear testimony on NASA's overall space program.

[Whereupon, at 11:57 a.m. Tuesday, March 25, the subcommittee was recessed to reconvene at 2 p.m. the same day.]

(AFTERNOON SESSION, 2 P.M., TUESDAY, MARCH 25, 1986)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ENVIRONMENTAL AND EARTH SCIENCE APPLICATIONS OF SPACE TECHNOLOGY

OPENING REMARKS OF SENATOR GARN

Senator GARN. The subcommittee will come to order.

This afternoon, we are continuing our hearings on the benefits of our national space program. We have with us a panel of distinguished individuals who will present testimony relative to the environmental and Earth science applications of space technology.

In our session this morning, it was observed that the principal planetary focus of our space exploration program is Earth, and we have found that the observations we can make from space of our own planet provide a bonanza of unique and extremely useful information.

This hearing segment is especially important in that orbital observations of the Earth represent a space technology that all of us have been exposed to and have already derived substantial benefit from, but it is also an area rich in promise, dependent on our willingness to continue our investment.

We certainly appreciate your willingness to alter your busy schedules, gentlemen, to join us today.

I should also note that through the kindness of the International Association of Firefighters, NASA, and Leviton Design, we have exhibits in the back of this hearing room which I encourage the audience to view following the conclusion of this session, if they haven't already had that opportunity.

Dr. Bretherton, you are first on our agenda. Please proceed.

INTRODUCTION OF SENATOR D'AMATO

Excuse me for one moment. I am used to Senator D'Amato coming in, and noticing him, but when he came in with me, I forgot him. [Laughter.]

Senator D'AMATO. Mr. Chairman, I assure you that my statement will be a short one because I, too, would like to hear the statements of our distinguished panelists.

Let me congratulate the chairman for continuing these important hearings. The environmental and Earth science applications of space technology are a vital part of the U.S. science policy.

I am sure, Mr. Chairman, that the National Center for Atmospheric Research, the National Oceanic Atmospheric Administration, and others have a unique opportunity to contribute to our understanding of the new environment. By using the space program, it is possible that much of the data gathered about the Earth and subsystems would not be possible without space science research. Its research potential for the future will prove valuable. Their comments, suggestions, and recommendations will prove most helpful as we move toward our future space program.

PREPARED STATEMENT

Mr. Chairman, I would ask that the balance of my remarks be included in the record as if read in its entirety. Let me thank our distinguished panelists and you, Mr. Chairman.

Senator GARN. Without objection, it will be.

[The statement follows:]

STATEMENT OF SENATOR D'AMATO

Mr. Chairman, the environmental and Earth science applications of space technology is a vital part of U.S. science policy.

Statements of the panelists attest to the importance of the space program in weather forecasting. We had satellite coverage of hurricanes Elena and Gloria. Millions of Americans were protected from the dangers of these hurricanes due to our early detection system. However, we need to focus attention on microwave radiation, as well. This technology penetrates clouds and would fill gaps in the data that presently limits our ability to model the atmosphere's behavior. This is just a sample of the planned activities that we should consider promoting for the benefit of this Nation.

In addition, the National Center for Atmospheric Research reports that there is a need for a new perspective on Earth science. Today's statement focuses on the need for understanding how the Earth functions as an entire system with special emphasis on the interactions between the atmosphere, ocean, rocks, and ice. These assessments best can be made in space, documenting changes that occur and providing a basis for computer models to anticipate change. These assessments can best be made with the concerted efforts of government, academia, and the private sector. This collaboration would provide needed information concerning the Earth and changes that may occur in the future.

Our ability to compete internationally depends upon a strong space program. Our commitment to the further development of this quality program will benefit our Nation. We will better be able to understand the space environment and the utilities of this special system. Moreover, the shuttle program promises great strides in scientific development.

The benefits of this program are enormous, as exemplified by the research conducted on previous shuttle flights; for example, electrophoresis research. It is vital that we learn more about space and the usefulness of its environment for American scientific advancement.

Mr. Chairman, the National Center for Atmospheric Research, the National Oceanic Atmospheric Administration, and others have a unique opportunity to contribute to our understanding of the environment by using the space program. It is possible that much of the data gathered about the Earth and its subsystems would not be possible without space science research. Its research potential for the future will prove valuable. Their comments, suggestions, and recommendations will prove most helpful as we move toward our future space program.

Thank you, Mr. Chairman.

EARTH SYSTEM SCIENCE COMMITTEE OF THE NASA ADVISORY COUNCIL AND NATIONAL CENTER FOR ATMOSPHERIC RESEARCH

STATEMENT OF DR. FRANCIS BRETHERTON, CHAIRMAN

Senator GARN. Dr. Bretherton, Chairman of the Earth System Science Committee of the NASA Advisory Council, and National Center for Atmospheric Research, please proceed.

Dr. BRETHERTON. For the first 2 years, the committee, of which I am chair, has been studying NASA's whole Earth looking program, and devising an implementation strategy for the future.

I am, of course, today, speaking really as an individual. Our committee's report, the overview will be coming out in the middle of May.

As human beings, we have a very deep interest in what is this world on which we live. How did life come to evolve here? What is our future on this planet?

These are, of course, the central questions of Earth science. Now, when we look more closely, we tend to specialize into different problems, into understanding the ocean, or the atmosphere, or the layers of rock and the sheets of ice on the Earth, and all the various forms of life.

VALUE OF SPACE TECHNOLOGY

Space technology has really contributed in very major ways to this understanding. One of the great achievements of the last 20 years has been the development of the weather satellite system. We are all familiar with these, of course, from the nightly TV, and as a major ingredient in our daily weather forecasts. What is often not so appreciated, that they are fundamental and essential scientific observations, we get from those satellites, of the cloudiness in the atmosphere, of the weather systems themselves, and of our overall climate. Also, they have been developed more recently to give indices of the development of vegetation in areas like Africa as it advances through the seasons, and the anomalies that take place in years of exceptional drought.

We have also had as a major advance the Landsat Program, which has given us unique insights into things like the geological structure of the Himalayas that we could have gotten in no other way.

MOVEMENT OF CONTINENTS MEASURED

We also have had, over the last 10 years, something which as a scientist I find particularly exciting, we can now measure the position of a baseline point on the surface of one of our continents to an accuracy of a few centimeters. We can measure that position relative to a similar point right around the other side of the world. By repeating these observations every few years for a decade or so, we have obtained the first direct measurements of the relative motion of the continents, of the drift of the continents, which has been one of the major breakthroughs in understanding the history of our Earth in the last 20 years.

We find that the continents are indeed moving slowly apart. In some places they are moving apart, and in some places they are moving toward each other, at rates which are simply about a centimeter or so a year, so that it takes hundreds of millions of years to open up the oceans as we see them today.

This type of measurement has been absolutely fundamental in understanding the history and evolution of the Earth on which we live.

Other things are going on. We have the first measurements, global measurements of the extent of sea ice, which is a major feature of the year-to-year variations in climate. We have had the first measurements of chlorophyl in the ocean. Our ability to detect from space changes in color of the ocean surface, which show up the distribution of small plankton, the primary life in the surface layers of the ocean. We have already discovered how, in springtime, there are great big blooms of such plankton over large areas simultaneously in ways that we had never dreamed before, we had those direct observations from space.

TOPEX PROGRAM PROVIDES OCEANS MEASUREMENT

Looking forward, we expect or hope very much to get more observations of the height of the sea level from the Topex Program. There is in the President's budget before you a proposal to have a new start on this Topex Program. So let me just elaborate a little bit what is at stake here.

By precisely tracking a satellite, and precisely measuring the difference from the satellite down to the ocean surface, we can measure thousands of miles from land the height of the ocean surface to an accuracy, again, of a few centimeters, and we can measure changes in that height from place to place, and from time to time.

We had, on the Seasat Program, some 7 years ago, a very brief proof of concept of this. Unfortunately, that satellite failed after only 3 months in orbit, and we only have a very brief sample of what can be done. But that has been enough to show the scientific community that we have here, for the first time, the ability to measure the near surface currents in the ocean simultaneously with the ability to measure the surface wind and the stress that that exerts on the ocean, which we can get from a scatterometer.

These two instruments enable us to look at one of the fundamental driving forces of our climate system, the indirection between the ocean and the atmosphere about it.

Great though these achievements have been, I would like for a moment to dwell a little bit on the real challenge that faces us in the future because we, the people of the world, are beginning to have an influence directly on our global environment in ways which we do not understand, and yet we know, from what we know now, we must be very concerned to establish the basis of that understanding in the future.

CARBON DIOXIDE INCREASING IN ENVIRONMENT

We do know that the concentration of carbon dioxide in the atmosphere is increasing rapidly, and over the next 50 years or so, it is expected to double. This increase is due to the worldwide use of oil, coal, and other fossil fuels. At this time, our best models predict that such a doubling would lead to a global warming comparable in magnitude to that which has already occurred in the past 18,000 years since the last ice age.

Now such a change—notice I am not saying, another ice age, I am talking about an increase in the same direction. Such a change has occurred a long time ago, hundreds of millions ago in the history of the Earth, but never in such a short time scale, and certainly not during the experience of human civilization.

We have to remember that over the past few thousand years, we as human beings have become accustomed to the climate in which we live, to the vegetation that we see as we go outside into the countryside, to our ability to grow crops under reasonably predictable circumstances. Changes of this magnitude will, in fact, take us into a regime in which our ideas of what is normal will have to be drastically revised.

Some of the changes may be beneficial, some may be detrimental, others may be of no great consequence. But we must anticipate there will be very far reaching changes as a result of these human impacts on things like carbon dioxide in the atmosphere, these changes taking place over the order of the next couple of generations or so.

It is not just the burning of fossil fuel and carbon dioxide that is of concern here. There are many other tell tales. The concentration of methane in the atmosphere is increasing rapidly. We don't really know why, but this appears to have been going on for the last half-century or so at an ever increasing rate.

The clearance of tropical forests, the impact of grazing in semiarid regions like the Sahal, or even in the western United States, the growth of large conurbations, all of these things are significant perturbations on the chemical and biological balances of the planet, not just the climate.

Our present knowledge is really inadequate to assess their potential impact or, indeed, to even describe the natural backdrop against which these changes have got to be evaluated. What we do see is the need for a long-term program of fundamental research into these vitally important problems.

This is a real challenge. It requires a completely new perspective on Earth sciences, not one where we simply look at the individual details one by one, is this actually an immediate benefit or is this going to solve this immediate problem.

We really have to understand the basic principles by which the Earth functions as an entire system, really concentrating on the interactions between the parts of the system, as much as on the individual pieces of it on which we have tended to focus in the past.

It requires a global view, a global view in which space technology has a unique contribution to make. It is certainly not the only technology we have to use here, but it is a unique one.

LONG-TERM OBSERVATIONS ESSENTIAL

The challenge requires a program of long-term observations, so that our successors, 20, 30, 40 years from now, can say what has changed, and be sure that the estimates of change are real, they are not artifacts of the way we made the observations.

We need those long-term observations as part of an integrated information system upon which we can draw to not only document the changes that are taking place, but to feed into our computer models to improve predictions about future changes which may be occurring or are likely to occur.

In some cases, as, for example, in the measurement of global rainfall and precipitation, we will need new observational techniques. In other cases, what we are talking about is the maintenance and cost-effective modifications of existing operational systems like the system of weather satellites that I mentioned earlier.

Now, a program of this sort requires not only those ingredients, but it also requires a new approach to setting priorities within the Federal agencies, and to collaboration between the Federal agencies, including a reaffirmation of the long-term roles and responsibilities.

Here, of course, particularly, we have NASA with a key role in the development of techniques, but we have the role of NOAA in terms of taking the long-term observations that are required. We will have the role of the National Science Foundation in developing a lot of the basic scientific understanding, particularly those in situ observations, which is necessary to achieve the global synthesis about which I am talking.

DEVELOPMENT OF INTERNATIONAL UNDERSTANDINGS

We also will require the development of new international understandings, both on the nature of the challenge and the scientific approach to addressing it, but also on the exchange of data and scientists between the nations of the world, the non-bilateral arrangements which will help spread the cost and enhance the capabilities of the program.

Above all, a program of this sort needs a commitment at the highest levels, a determination that this set of problems is so important that we have to start now to establish the long-term basis of our understanding.

A lot is already going on, a lot has been achieved in the past, but what we are talking about here is a new vision as to how these pieces tie together, and of the fact that we cannot haphazardly start and stop key programs, that we have to be sure that what we are doing now is everything the prudent person would be doing to lay the basis for the understanding of the problems which future generations will be facing because of our present activities.

We must start now. We owe this to our children, and to our grandchildren.

[The statement follows:]

STATEMENT OF FRANCIS P. BRETHERTON, CHAIR, EARTH SYSTEMS SCIENCES COMMITTEE, NASA ADVISORY COUNCIL

What is this world on which we live?

Why and how did life evolve here?

What is our future?

These are central questions of Earth Science, for which the focus is the Earth; its oceans and atmosphere, the layers of rock and sheets of ice, and the various forms of life. Scientists have long sought the laws that govern the evolution of this planet and the workings of its various components. Space technology has contributed to this search in outstanding ways, such as the network of weather satellites, the direct measurement of the drift of the continents, the imaging of the land surface, and we anticipate still greater benefits by taking into account new scientific insights and observation technologies, both in situ and from space.

A signal opportunity to open new frontiers of understanding the ocean circulation and its role in the complete Earth system is the TOPEX mission, proposed by NASA in the FY 87 budget before you in collaboration with the French Space Agency. Measurement of the height of the ocean surface to an accuracy of a few centimeters thousands of kilometers from land will enable for the first time determination of the near surface currents on a global basis, and, in conjunction with data from the scatterometer to be flown at the same time on the N-ROSS satellite, the response of the ocean to changing winds in the atmosphere above. Only by observing in this way how the ocean and atmosphere interact can we unravel how the climate system functions and its sensitivity to the longer term changes expected in the future.

For, great though the achievements and advances in scientific knowledge have been to this point, the most profound challenge and the fulfilment of their true promise still lies in the future.

This planet is our home; the source of all we need for life, the environment which we must master in order to survive, and the heritage which we must pass unsullied to future generations. Over the course of human history we have learned to grow high yielding crops, to fly through the atmosphere, to extract oil in the arctic, and to explore the depths of the oceans and the vastness of space. We have learned to expect normal fluctuations in our environment; in day to day weather and in the progression of the seasons. We have learned to live, more or less, with droughts and storms, with the richness of harvests and the tragedies of pestilence. We have adapted. We have exploited. On the whole, we have prospered.

Yet evidence is accumulating that through this economic and technological activity we, the peoples of the world, are now affecting our environment on a global scale, in ways that are poorly understood, but fundamental to much that we take for granted.

The concentration of carbon dioxide in the atmosphere is expected to double within the next 50 years or so due to the worldwide use of oil, coal and other fossil fuels. Our best models at this time predict this will lead to a global warming comparable to that which has already occurred in the 18,000 years since the last ice age. Though not unprecedented in the history of the earth, changes of this magnitude have not occurred in so short a time and are quite foreign to the collective experience of our civilization. As we move into the future such a change in temperature and associated patterns of rainfall and biological productivity would require new definitions of normality, new adaptations, and new recognition of fundamental constraints. Some of these changes may be beneficial, some detrimental, and some of no consequence. If we understand in time what is happening, change may be quite stimulating. If we do not, adjustment will almost certainly be painful.

There are also other aspects of concern. Methane is also increasing rapidly, for reasons which are more controversial, but its effects on climate may be as large as those due to fossil fuel. The clearance of tropical forests, the impact of grazing in semi arid regions, the growth of large conurbations, all are significant perturbations on the chemical and biological balances of this planet. Our present knowledge is inadequate to assess the potential impact of these human activities, or indeed to describe the backdrop of natural variability within which they must be measured. Advances in the past few decades have laid a firm foundation, but fundamental research is a long term activity, and for future generations to have the basis they will need for action, we must be responding now.

This challenge requires a new perspective on Earth Science, transcending traditional disciplinary boundaries and agency reponsibilities. It requires understanding of how the earth functions as an entire system, concentrating as much on the interactions between the atmosphere, ocean, rocks and ice and the biological subsystems as on the phenomena within them, and revealing the relations between processes that occur on quite different time scales. It requires a global view, exploiting the unique opportuniites for observing Earth processes from space in close coordination with other appproaches. It requires a program of long term observations, both in situ and from space, to document the changes that do occur, and to provide the basis for computer models to anticipate those that may. It requires an integrated information system, drawing upon data from a wide variety of existing operational and research observational systems and from those still evolving. It requires in some cases the development of new observational techniques, in other cases cost effective modifications of operational systems maintained for other purposes. It requires a new approach to setting priorities within the federal agencies, including reaffirmation of long term roles and responsibilities. It requires the development of international understandings, on the nature of the challenge and the scientific approach to addressing it, on exchange of data and scientists, and on bilateral arrangements to enhance the program. It requires better working understanding in detail of the roles of government, the academic community and the commercial sector in instrument development and in data access. Above all it requires a commitment, at the highest levels, to a program which will address these concerns in a far seeing coherent manner.

The challenge is great. Much is already happening, thanks to the vision and persistence of concerned individuals both within and outside the U.S. government, but these scattered haphazard efforts cannot match the sustained commitment required. The requirements are daunting. The organizational problems are severe. Resources are scarce. However, to achieve our goal we must first begin. We owe it to our grandchildren.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

STATEMENT OF J. CURTIS MACK II, DEPUTY ADMINISTRATOR

DEVELOPMENT AND DEPLOYMENT OF WEATHER SATELLITES

Senator GARN. Mr. Mack, we are happy to have you with us today. If you would like to proceed.

Mr. MACK. Thank you, Mr. Chairman, and Senators. I am happy to be here today to call attention to the accomplishments of the National Aeronautics and Space Administration [NASA] that perhaps have not gotten the credit that they deserve.

When NASA is mentioned, the average person thinks of manned space flights, visits to the Moon, and flybys of incredible distant planets. We, in NOAA, however, think of NASA as an essential partner in an equally amazing and successful space adventure: the development and deployment of the weather satellites.

Just about this time last year, the Congress itself paid tribute to this achievement by issuing a joint resolution commemorating the 25th anniversary of weather satellites. It noted that these spacecraft have brought unique and invaluable benefits to the American people and to the world community, and are essential in detecting, tracking, and giving early warning of hurricanes, severe local storms, flash floods, and other life-threatening natural hazards.

Weather satellites also have contributed significantly to improvements in the accuracy of daily weather forecasts. In addition, they have evolved into true environmental satellites that also monitor ocean conditions, snow and ice cover, frost, vegetation, forest fires, and even volcanic eruptions.

The global coverage of environmental satellites also has made possible a dramatic new international humanitarian service, search and rescue from space. The program has saved more than 535 lives since it began in 1982.

NASA/NOAA PARTNERSHIP

These achievements have all contributed significantly to U.S. leadership in satellite technology and in the peaceful uses of outerspace. All are the result of a highly successful NASA/NOAA partnership that began early in the development of our present environmental satellite system.

In this partnership, NASA has developed and demonstrated experimental prototype satellites and instruments, while the Department of Commerce and NOAA have operated the satellite system to support weather forecasting and other applications.

Before the advent of this satellite system, weather observations were available for less than one-fifth of the globe. Little, if any, information was obtainable for the polar regions or for vast stretches of Asia, Africa, and South America. Over the oceans, tropical storms grew to maturity, undetected until they sank a ship or devastated an inhabited island or coastline.

Today, environmental satellites provide practically continuous monitoring of both atmosphere and ocean on a global scale, allowing scientists of all nations to follow the ebb and flow of worldwide weather and ocean patterns. Since the startup of the U.S. operational satellite service in 1966, no tropical storm has gone undetected anywhere in the world.

Like the rest of the space program, the development of the environmental satellite system has been made possible by the strong and continuing support of the Congress and the ingenuity and joint efforts of both Government and the private sector. It has been a remarkably successful program that has brought great benefit to Americans and to the global community. NASA has played a major role in this achievement.

Thank you, sir.

Senator GARN. Thank you, Mr. Mack.

[The statement and questions and answers follow:]

STATEMENT OF J. CURTIS MACK, II

Deputy Administrator of the National Oceanic And
Atmospheric Administration (NOAA)

Mr. Chairman and Members of the Subcommittee. I am happy to be here today to call attention to accomplishments of the National Aeronautics and Space Administration (NASA) that perhaps have not gotten the credit they deserve.

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QUESTION SUBMITTED FOR THE RECORD BY SENATOR JAKE GARN

NASA/NOAA Partnership

Question: Mr. Mack. I realize you are relatively new to the space business. NASA and NOAA have had a successful relationship with NASA performing the research and development to get environmental sensing satellites to an operational stage and NOAA then taking over the operation of the satellite systems. I hope that you will serve as a good influence to foster the cooperative efforts between the two agencies.

Do you have any general comments you want to make?

Answer: As articulated in my statement for the record, NOAA and NASA have a long history of cooperative activities in the environmental sensing satellite field. It is my intention, and that of the Agency, to continue working closely together in research, development and operations to provide for the most modern and cost effective environmental satellite data possible and to maintain a high level of environmental monitoring and provision of data to various users in both the public and private sector.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE D'AMATO

Weatherization Research

Question: For example, could you give a status report on the weatherization (global climate) research and other (atmospheric) research that has been conducted with assistance from the Shuttle?

Answer: None of NOAA's global climate research or other atmospheric programs utilize instruments flown on the Shuttle or are otherwise dependent upon the Shuttle.

Civilian Operational Weather Measurement

Question: What would be the impact of delays in the Shuttle program on the launching of weather satellites?

Answer: At this point, we do know what the effects will be, if any. Our first Shuttle launch for meteorological satellites is not scheduled until 1990. We have expandable launch vehicles (ELVs) reserved for our current inventory of satellites between now and 1990. Given the long lead-time before the first Shuttle launch and the fact that our launches are assigned high priority in the Shuttle program, we do not expect launch delays.

GEOBOTANICAL REMOTE SENSING, JET PROPULSION LABORATORY

STATEMENT OF BARRETT N. ROCK, GROUP SUPERVISOR

Senator GARN. Next, Mr. Barrett Rock from JPL.

I understand that you have some slides, so at the proper time in your presentation, we will turn down the lights so that you can show them to us.

Mr. ROCK. Thank you, Mr. Chairman.

First of all, I would like to thank you very much for giving me this opportunity to describe to you an ongoing research activity within NASA. I am a Vermont native, and from long-standing, I have had an interest in the Green Mountains of the State of Vermont.

Senator LEAHY. I might say, Mr. Chairman, that when Mr. Rock has shown us the slides, and we go to the question and answer period, I have the slides here in a print, and we will be able to ask our questions with the lights back up for that part.

Mr. ROCK. Very good. Thank you, Senator Leahy.

DECLINE OF VERMONT HIGH-ELEVATION FORESTS

As I was saying, I have been aware of the fact that certain components of high-elevation forests in the State of Vermont have been undergoing a very rapid decline. This particular study is a joint project funded by NASA. It involves personnel from the Jet Propulsion Laboratory, as well as the Goddard Space Flight Center. We have been looking at a site known as Camels Hump in Vermont.

I would like to enter my prepared text as part of the record, but would also like to be able to give a rather informal dialogue covering the slides that will be presented.

Senator GARN. We will place your full testimony in the record at the conclusion of your oral presentation.

Mr. ROCK. Thank you. If we could have the lights out.

[The lights were dimmed.]

Mr. ROCK. Is it possible to have the television lights off?

[The television lights were turned off.]

SPECTRAL CHARACTERIZATION OF FOREST DECLINE DAMAGE IN RED SPRUCE

Mr. ROCK. The title of this joint research effort is "Spectral Characterization of Forest Decline Damage in Red Spruce." As you can see from this first slide, it involves personnel from the Jet Propulsion Laboratory and Goddard Space Flight Center, as well as the University of Vermont, the University of California at Los Angeles, and some German researchers. We have also spent some time in the Black Forest of Germany looking at spruce damage in similar fashions to the approach used in Vermont.

This is Camels Hump Mountain, and I think even under these lighting conditions, we can see why the mountain is so named. I would mention that Camels Hump is the site of an ongoing ecological study that was initiated at the University of Vermont in the mid-sixties. As a result, this particular mountain offers an extremely valuable data base against which to compare current observations.

I would also point out that the upper summit area is of barren rock outcrop, and that particular feature will show up on some of the satellite and aircraft images that I will show shortly. The uppermost summit is approximately 4,000 feet in elevation.

Senator LEAHY. I might note, if you look out from the front porch of my home in Vermont, that is almost exactly the view, the one just before this.

Mr. ROCK. I envy you.

This is an aircraft image acquired with a device known as a thematic mapper simulator, and the various numbered sites represent our study sites on Camels Hump and adjacent areas. Sites 1, 2, and 3 represent low damage to spruce. Sites 4 and 5 represent medium damage. Sites 6 and 7 represent high damage. By low, medium, and high damage, I am referring to foliage loss or needle loss from the vegetation. Low-damage sites would be characterized by perhaps 12- to 20-percent needle loss; high damage sites as much as 80-percent needle loss. Within Vermont, we have found no true control sites, or totally undamaged areas.

This slide shows an example of a highly damaged tree, just to give you a feeling of what the conditions on the ground are like, you can see completely through the canopy, through the foliage area. This is a tree that is all but dead.

One of the enigmas of the so-called acid rain forest decline problem is that adjacent to very unhealthy trees, one may find trees that look quite healthy. On the far left-hand part of the slide, you can see the branches and boughs of what appears to be a very healthy tree.

However, using a spectral approach, we find that even those trees that look healthy are, in fact, unhealthy.

This is what one would see from the summit, looking back toward Senator Leahy's front porch, perhaps, and what one sees, of course, is a fair amount of dead vegetation, but also a lot of damaged but living trees in this area.

As part of this joint effort, we employ NASA aircraft, in this case the C–130, and a helicopter from Wallop's Island, and as the insert on this helicopter photo show, there are remote sensing sensors attached to both aircraft. The sensors include existing satellite sensors, or duplicates of satellite sensors, such as the thematic mapper. In addition, some advanced sensors that provide very high spectral resolution data sets. We will talk a bit more about those shortly. Thus we are comparing current state-of-the-art with advanced experimental sensors to see which of the two does the best job in detecting, and hopefully quantifying, the damage the eye sees.

FIELD SPECTROMETER

This slide shows a field spectrometer, and one of the strengths of the JPL-Goddard effort is to have teams on the ground at the time of satellite overpasses, or at the time of aircraft overflights, measuring with precision trees of different damage levels using such instruments as this field spectrometer.

The field spectrometer produces squiggly lines, and the squiggly lines represent reflectance values in the visible component of the electromagnetic spectrum, but also components known as the infrared region, out beyond the area visible to the eye.

It turns out that in looking at forest decline damage, the longer wavelength infrared information is extremely valuable, in fact more valuable than the visible component.

Notice, along the top of this particular slide, that there are three dominant factors within the leaf that control reflectance characteristics. One would be the leaf pigments that influences the reflectance in the visible. Second, the cellular structure, and here the reflectance values seen in the near infrared region can be an accurate indicator of the amount of leaf tissue that one is seeing, as well as the actual state of cellular health.

Also note that at the longer wavelengths, leaf water content plays a dominant role in influencing reflectance variables. It is this leaf-water content which we feel is the single leaf variable that we have been able to detect using our aircraft sensor systems. It is that variation in leaf-water content, as well as variation in cellular health that allows us to produce the next images that I will show.

This slide is simply a comparison of spectral fingerprints, if you will, of a healthy tree, that is the uppermost curve, and a very damaged tree, the lowermost curve, but nonetheless one of those trees that looked healthy to the eye. You can see that in the visible portion of the spectrum there is very little difference, therefore, it is not surprising that it looks healthy to the eye.

However, in the region influenced by cellular health, and in the region influenced by water, there are differences that remote sensing systems detect with ease, and those differences can then be converted into images.

This is an example of such an image. The image on the left is the one similar to the one I showed earlier, with the numbered sites, and it allows us to locate ourselves on the ground. The image on the right is a so-called color density slice of a particular spectral band ratio from aircraft data, and the colors that are assigned are related to levels of damage. You might note that there is a series of seven colors, ranging from red down to the blues and the purples, that relate to damage. Researchers on the ground are able to recognize six or seven levels of damage. German researchers recognize only four levels of damage. The seven that are recognized here correspond with precision to those levels recognized on the ground with visual assessment.

DAMAGE ON WEST-FACING SLOPES

I might point out that the rock outcrop at the upper summit of Camels Hump shows up as a boomerang shaped feature in the center of that image. North is up in this particular image, and it has been recognized since the midseventies that the forest decline damage is exaggerated on the west-facing slopes compared to the east-facing slopes.

You can see that the red coloration corresponds to the west-facing slopes. As one goes to the east, one sees only the medium damage, color assignment and that corresponds precisely to the kind of damage that the researchers on the ground see. As one goes to lower elevations, one finds very low damage, and that corresponds with ground assessments.

What I am showing in this slide is simply a comparison between the spectral ratios derived from the aircraft data plotted along the vertical axis against ground assessment by visual assessment along the baseline. This shows a very strong one-to-one correlation between visual damage assessment and this particular spectral ratio. These results are the same as 94 percent accuracy. This is better than photo interpreters can do. This is better than researchers on the ground can do using eyes alone. It represents a very accurate means of recognizing damage, and not only recognizing damage, but quantifying it, that is, assigning levels of damage, which is an extremely important ability.

Now, if we expand the area of coverage, we get lost. This is a pretty colored picture, one which you might enjoy hanging on an office wall, but it is difficult to locate yourself. There is a lot of information here, but it tends to get lost in all of the colors. It is difficult to see topographic information, what is representing high elevation versus low elevation, for instance. It is also possible to end up with farmers' fields giving us some false alarms, appearing to look like forest damage, when in fact it is a wheat field that is dry, but certainly is not a damaged forest.

To get around problems of lost topographic information and false alarms, one can use the density slice information, that spectral ratio, that spectral fingerprint, if you will, which represents the damage, in combination with raw band data which then give you the topographic information and the cultural information that you would like to see.

We can see on this slide that, again, the west-facing slope of Camels Hump, in this case north is off to our left, you can see the west-facing slope represented by sites 6 and 7 are very high damage. Site 4 shows up as a medium-damage site. Sites 1, 2, and 3 as low-damage sites.

If one expands the area of coverage, goes beyond the aircraft sensors, and uses satellite data, one gets much the same information. This slide is an image acquired by the thematic mapper onboard Landsat 5, data acquired on June 10, 1984. This is of the central part of the State of Vermont. We can pick out areas, such as the granite quarries, the Waterbury Reservoir, a wide number of different cultural features. The image is approximately 40 miles on the side. It is important to note that this is only approximately one-sixth of the full Landsat scene, so it is by no means all of the information that can be gathered.

EXTENSIVE DAMAGE

This is the image that Senator Leahy has a hard copy of. If we look at the central spine of the Green Mountains, we see that the red color, that is, high damage, is extensive. In fact, this represents a dramatic increase in the amount of damage that had been recognized previously in the State of Vermont.

One can also compare between mountains, or among mountains, to see if Camels Hump is unusual. Perhaps, Camels Hump, for one reason or another, is showing a dramatic amount of decline, and other mountains are not. That clearly is not the case.

We have recognized, using this image and some sophisticated analyses techniques, that evergreen forests, above 2,000 feet in elevation, a full 80 percent of them along this region of the Appalachians and Green Mountains, is classified as either moderate or heavy damage.

At higher elevations, the damage is very, very widespread. It is startling to see this amount of damage.

THREE LEVELS OF VEGETATION RESPONSE

Now I would like to summarize by simply indicating that when vegetation is exposed to a stress agent, it could be a variety of things, drought, acid rain, ozone, heavy metal stress, the vegetation is going to respond. If the stress is chronic, long term, and severe enough, there will be a sequence of three levels of vegetation response, a biochemical response, a morphological response—in other words, one that the eye can see—and then if the conditions are bad enough, the primary state of vegetation is going to change, it is going to give way to species that are more tolerant of whatever the condition happens to be, therefore, giving rise to the secondary vegetation state.

On Camels Hump that is exactly what we are seeing. We are seeing spruce and fir forests changing slowly—actually rather rapidly in a geologic sense—rapidly into a birch community. The spruce and fir forests are simply dying out in Vermont, in New England, as well as the Black Forest regions of West Germany.

I would also point out, on the right-hand side of this slide are features of biochemical response, or morphological response, of community composition response that can be remotely detected using airborne and spaceborne sensor systems.

I would also point out that the biochemical level of response is a previsual response. It is one that the eye doesn't see, but the multispectral sensor approach allows one to see. With some of the newer, advanced sensor systems such as the imaging spectrometers that are being developed, we are likely to be able to see and recognize more and more of the spectral signatures associated with these biochemical level responses.

Last, but not least, this slide represents the German approach to solving the problem, and that is to crush limestone and then blow it out into the forest, the hope being that this is going to help the trees.

If we develop means of monitoring vegetation change, not only will we be able to see the increasing damage, but if we begin to take corrective measures, we may begin to see what effect the corrective measures are having in terms of water conditions within the tree, the state of cellular health, and overall vigor of the forest at higher elevations.

[The statement and questions and answers follow:]

STATEMENT OF DR. BARRETT N. ROCK, HEAD, GEOBOTANICAL REMOTE SENSING RESEARCH GROUP, JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, NASA

Mr. Chairman and distinguished members of the Subcommittee:

Considerable damage to high elevation forests in Vermont has been well documented since the early 1960s, and since 1965 red spruce, particularly, has shown a marked decline in growth rate and vigor in high elevation forests throughout the northeastern United States. This decline is marked by needle loss and reduced growth leading to death. Similar declines have been studied in Norway spruce and white fir communities in European forests. Causes of the declines have been disputed, but there is growing evidence that high inputs of air pollutants (ozone and acid deposition) into the forest systems may be a significant factor.

NASA has demonstrated that remote sensing can be used to detect and quantify this damage. Jet Propulsion Laboratory's Geobotanical Remote Sensing Research Group has used airborne and spaceborne multispectral-scanner data to map both the level and extent of such forest decline in selected areas of New England.

Remote sensing techniques are being used to detect and quantify the forest decline damage and, using such an approach, we could monitor these changes in the forests through time. We are also studying spectral "fingerprints" that might be useful in associating the damage symptoms with certain biophysical parameters, that is, changes in leaf variables such as pigment concentrations, internal structural alterations, biomass properties, etc., which in turn may be suggestive of causal agents contributing to the decline.

The research group is currently studying forest-decline sites at Camels Hump Mountain in Vermont and in the Black Forest of West Germany. The primary focus of the research has been detailed field work leading to spectral characterizations of spruce-decline symptoms detectable in both the visible and infrared portions of the electromagnetic spectrum. Efforts have been made to correlate the spectral "fingerprints" associated with the decline symptoms with biophysical and biochemical conditions in affected areas in both the United States and West Germany. The spectral signatures seen in both countries are very similar, with the exception of the chlorosis (yellowing) related differences seen in the German specimens.

Red spruce samples from the high damage areas, when compared to samples from low damage areas, are more reflective in the red portion of the visible and less reflective in the near infrared portion of the spectrum. These changes in reflectance properties are now suspected to be associated with changes in leaf chlorophyll conditions and state of cellular health in affected needles.

Certain spectral features, such as changes in reflectance in the near and short wave infrared, are readily detected by aircraft and orbital multispectral scanners such as the Landsat Thematic Mapper. They have been used to produce damage assessments of a number of areas in Vermont. The maps, shown during the course of this presentation, quantify as well as define areas of damage. They have been shown by detailed field studies to be highly accurate, and have led to detection of new areas of damage previously unrecognized. As a result of applying this approach to satellite data acquired for the central portion of Vermont, the extent and level of damage to forests has been shown to be more extensive than previously thought.

This study was the first time that analysis of Thematic Mapper data has been used to detect and quantify forest decline suspected to have been caused by acid deposition carried by rain or other forms of precipitation. Further analysis of spectral and physiological symptoms will lead to a better understanding of the potential causes of global forest-decline problems.

The use of remote sensing to detect and quantify the biophysical symptoms from orbital platforms of large areas is providing the scientific community with invaluable data obtainable in no other way.

Conclusions

A - Forest decline damage is detected and quantified using satellite data, and has been shown to be more extensive than previously thought.

B - Forest decline could be monitored through time.

C Spectral features have been correlated with biophysical parameters.

D - Research is leading to development of spectral fingerprints associated with specific causal agents.

QUESTIONS SUBMITTED FOR THE RECORD BY SENATOR ALFONSE D'AMATO

Question: For example, could you give us a status report on the weatherization research and other research that has been conducted with assistance from the shuttle?

Answer: Earth remote sensing research conducted with assistance from the shuttle includes optical and microwave (radar) sensors. As the result of a shuttle experiment known as SMIRR (Shuttle Multispectral Infrared Radimeter), surface materials such as clays and various soils were identified on the basis of their unique spectral properties. This marked the first time this type of activity was conducted from space and demonstrates some of the future potential of the imaging spectrometer type of Earth remote sensing systems.

The Shuttle Imaging Radar (SIR) experiments have demonstrated the utility of using radar systems in Earth orbit to survey areas of deforestation due to lumbering activities in South America. Because of nearly constant cloud cover in large portions of the tropics, such a radar approach is the only way of conducting vegetation surveys in parts of the world such as South America.

Question: What types of studies have been planned for future shuttle flights, especially those that might not have been initiated without findings from previous studies conducted with the aid of the shuttle?

Answer: As a result of SMIRR experiments conducted during the second flight of Columbia in November of 1981, a new type of Earth remote sensing system known as the Imaging Spectrometer was developed. SMIRR demonstrated the potential of direct identification of surface materials from orbit, based on spectral properties, thus providing the basis for developing such sensor systems as the Shuttle Imaging Spectrometer Experiment (SISEX). SISEX was orginally scheduled for launch in the early 1990s, and, once launched, will constitute the first step in developing a new generation of Earth-orbiting satellite sensors.

VISUAL EFFECT HELPFUL

Mr. ROCK. Are there any questions?

Senator LAUTENBERG. Mr. Rock, before we leave this slide, has it helped, or has it been a continuing process? I am just curious.

Mr. ROCK. It has had a visual effect. The trees look healthier for a short period of time. One of the symptoms in Germany that we have yet to see in Vermont is a symptom known as chlorsis. It is a yellowing of the trees that is due to a dieback of chlorophyll. The limestone that is crushed is rich in magnesium, and as a result it gives a rather quick response, the trees look greener. However, the multispectral data would suggest that we haven't addressed two of the other problems that the tree has.

Senator GARN. Professor Suomi, before we turn to you, Senator Leahy has another appointment that he needs to go to, and I am going to let him ask Mr. Rock some questions before we proceed.

Senator Leahy.

Senator LEAHY. Mr. Chairman, I thank you for that. It is typical of the courtesies you have always shown on this committee.

Mr. Rock, I am delighted you are here. Like you, I am a native Vermonter, and I grew up in much the same area. I see my hometown of Montpelier on some of these pictures. In fact, I notice that you have Montpelier carefully shown here, and I can even follow the road up and see up to my farm in Middlesex.

DAMAGE TO CAMELS HUMP NOTED

I don't want to do a travelog with, but when I look out the front window of my home in Middlesex, I can see Camels Hump, I can see the effects of the acid rain.

I was comparing some pictures that we had taken from our frontyard over the last 20 years of Camels Hump. In the past few years, it is almost like somebody has taken an eraser across the top third of Camels Hump. You can see, at least to the unpracticed eye, some damage.

When I look at your material here, which I find very impressive from your testimony, and probably the most dramatic photographs I have seen of that, you say that these fingerprints are probably air pollution related. Why do you say, "probably"?

Mr. ROCK. Well, I think that we have to be careful. It is difficult to tie the two together. I think the kinds of spectral fingerprint variables that we are seeing from Camels Hump are suggestive of cellular damage and of metal stress that could easily be related to pollutants of one form or another.

Perhaps what is really needed is a series of greenhouse experiments which could influence vegetation with ozone, with acid mist, with sulphur dioxide, et cetera, and then begin to look at the spectral fingerprints associated with those controlled experiments. Perhaps in that way, one can begin to close the loop, begin to identify specific causal agents.

Senator LEAHY. Mr. Rock, I have been a strong supporter, and the committee has been very good in going along with this, I have been a strong supporter of having this type of aerial photography, the spectrographic analyses that have been done in Vermont, and I have compared it with the pictures we have had from NASA and others and what I have seen on the ground.

VALUE OF SATELLITE SPECTRAL IMAGES

Do the satellite spectral images like this show more or less damage to the forest in Vermont than you had supposed would be there?

Mr. ROCK. I think there has been a tenfold increase in the amount of damage recognized within the State as a result of producing these images. Prior to the aircraft overflights, there were faculty members at the University of Vermont, and foresters within the State, who were focusing the bulk of their efforts on two mountains, possibly three, Camels Hump being perhaps the primary site.

The areas that we now recognize as damaged extend along the entire Green Mountain chain, and are certainly not restricted to Camels Hump. I would say, we are looking at approximately a tenfold increase in the amount of damage when compared with that previously suspected.

Senator LEAHY. Mr. Rock, I knew that this was going to be your answer, and I wish it wasn't your answer, because I have hiked those same places with Professor Vogelman. In fact, we had Lee Thomas up there last year. I must tell you that I find it distressing to hear you say that the damage is 10 times worse than expected.

If we wanted to obtain the same kind of information for the whole eastern United States, assuming that we could use satellites to do it, how long do you think it would take?

Mr. ROCK. Assuming the data sets already exist in our archive of thematic mapper data from Landsat, and certainly for most of the areas, they do, it could be a fairly quick process, something on the order of perhaps 6 months to a year. Knowing how many satellite images we would need in order to include the entire eastern United States is something that I don't have at my fingertips. But if we wish to do New England alone, one would need approximately 19 satellite scenes.

So to get to the question of how quickly it would take, that could be done reasonably quickly, within a 1-year period.

Senator LEAHY. Let's just assume that you could just go out and recruit anywhere you want, on college campuses, and everything else, to get volunteers to do this on foot, could you even do it in this century?

Mr. ROCK. No.

Senator LEAHY. So you are really talking about something that would be impossible to be done otherwise.

SYNOPTIC OVERVIEW

Mr. ROCK. I think that the real value of remote sensing is that it provides a synoptic overview, it gathers data over large areas simultaneously, and that is something that hundreds of thousands of people on the ground could not do. When you add to that the fact that the satellite sensors see spectral areas that the eye does not see, areas that the eye is not sensitive to, and areas which are very important in terms of mapping of the damage, even if you had people, thousands of them on the ground, they would not see the same information the satellites sensors can see.

Senator LEAHY. You know, Mr. Chairman, this is an outstanding example of what space technology can do. I think that there are a lot of things that are going to come out of this set of hearings that we are going to have here about what space technology has done. But, as a Vermonter, I can't think of anything that is going to hit home more than this.

It is something that can be done. It's something that we need to do throughout New England, and that we couldn't conceive of doing any other way. There really is no other way.

It also tells me and Mr. Rock that our forests are damaged 10 times worse than I had expected. I think that something like 80 percent of the high forests in Vermont are moderately or heavily damaged. I don't know how much more we have to say about why we have to do something on acid rain. We have the technology to show the damage. We have the technology to show where it is. We have identified where it is. I hope now we will have the political will to do something to stop what is causing the damage.

I applaud you, and I applaud those at the University of Vermont who are working with you on this.

When I look at an area that I know so well, that I have hiked over, that you have hiked over, and everybody else has, to be able to actually see at a glance exactly where the damage is, it is sobering.

I think that I will keep these two photographs to show a lot of my colleagues over and over again until they are sick of seeing them, and show them why we have to do something about acid rain.

Thank you very much.

Mr. ROCK. Thank you, Senator.

Senator LEAHY. Thank you, Mr. Chairman, for your courtesy.

Senator LAUTENBERG. Mr. Chairman, could I put a question, to follow up on Senator Leahy's questions?

ADIRONDACKS AND WHITE MOUNTAINS DAMAGE

Do you see the same kind of damage in the Adirondacks, or the White Mountains?

Mr. ROCK. We haven't looked there as yet. We have data from those areas. I might mention that the general trend is that mountains to the west are more heavily damaged. Certainly White Face Mountain in the Adirondacks is very heavily damaged. Mountains to the east are suspected of being less damaged, and within that scene that Senator Leahy has just held up, we have been able to compare one mountain over on the far right-hand border, a mountain known as Spruce Peak, and Spruce Peak is to the east of Camels Hump, it shows only 9-percent damage at the higher elevations. It is nearly as high as Camels Hump, nearly as high as the other mountains.

So I would suspect, in answer to your question, that the areas in the Adirondacks are very likely to be heavily damaged, and those in the White Mountains are likely to be less damaged.

Senator LAUTENBERG. Is that true also for the forests in New Jersey, the Pinelands, which reflect acidity in fairly large quantity?

Mr. ROCK. We have not looked there.

Senator Lautenberg. Thank you.

Senator GARN. I would simply say, for Senator Leahy's benefit, that the bad news is that it is 10 times worse than you thought, and the good news is that had we not known, there would be much less chance of trying to do something about it. From that standpoint, it is very helpful to find out exactly what the damage is.

Mr. ROCK. One needs to know where your enemy is, even if you don't know who he is. We are working with the spectral fingerprint approach at developing an understanding of who he is, as well as where he is.

Senator LEAHY. I can't overemphasize enough what the chairman said, because, as Mr. Rock knows, the University of Vermont and others are painstakingly trying to establish this, using volunteers, academics, and everybody else, but day-by-day walking up the mountain, checking things almost tree by tree by tree. None of us would live long enough to fully show the damage.

Mr. ROCK. The forest will surely not live long enough.

Senator LEAHY. The forest surely would not live long enough for us to catalog the damages. Here we have shown, by space technology, that we can do it within a matter of days. I think that it emphasizes exactly what the chairman said, and I agree with him.

Senator LAUTENBERG. Have you looked at the Wasatch, Mr. Chairman, and is there damage?

Senator GARN. Not anywhere near to the extent that this is taking place. One of the major reasons is, obviously, the winds blow from west to east, and we are fortunate, what coal we burn in Utah is very low sulphur coal. A plug for Utah coal, if we could burn it in the East, it would help alleviate that problem.

It is true, it is interesting that our coal will burn cleaner with less sulphur emissions, without scrubbers, than a lot of eastern coal after it has been scrubbed. That is one of the reasons that we fight the percentage reduction because we are cleaner with no scrubbing than some other coal is with scrubbers.

Senator LAUTENBERG. Mr. Chairman, remember who the minority leader is, and what State he comes from.

Senator GARN. I understand.

SPACE SCIENCE ENGINEERING CENTER, UNIVERSITY OF WISCONSIN

STATEMENT OF PROFESSOR VERNER E. SUOMI, DIRECTOR

Senator GARN. Dr. Suomi, we would like to turn to you now, please.

Dr. SUOMI. Thank you, Mr. Chairman.

I would like my remarks that have been printed to be put in the record, but I will try to hit some of the high points.

Senator GARN. We will include your full testimony in the record.

Dr. SUOMI. Thank you very much.

First of all, I have been closely involved with the weather satellites since the beginning.

Senator GARN. Would you pull the mike a little closer so that the people in the back can hear you.

Dr. SUOMI. I have been very closely involved with the Weather Satellite Program from its beginning. I can tell what progress has been made, and maybe give you some idea of the future.

BETTER WEATHER FORECASTING

Recently, we all witnessed a great tragedy in the space program, and it will take time to recover from this tragic loss. At times like these, we tend to forget or ignore the real triumphs of the program. I would like to tell you about a few where the space program has contributed to better weather forecasting.

I would like to emphasize just a few of these. For example, during the last hurricane season, we had superb satellite coverage of Elena and Gloria. As a result of the coverage of Elena, millions of citizens about to spend their Labor Day holiday on the gulf coast were kept out of danger despite the erratic behavior of this dangerous storm. As a result, only a few lives were lost in a situation where thousands could have been.

It was the visualization of the storm on TV that made it possible for the citizens to see this growing monster. In previous years, we knew the storms were there, but I think in this instance, it was the visualization on TV which made it possible.

Now the tornado season is on us, and the progress here has also been very important. Most people don't have an idea of how really violent these storms are. In my experience, in a little town about 20 miles from Madison called Barneveld, the entire town was wiped out. It made the water tower look like the Leaning Tower of Pisa, and a bumper with a license plate still attached was torn from a van and found 26 miles away. That was incredible.

I am happy to say that our ability to forecast these destructive storms in the last several years has improved dramatically thanks to the geostationary satellites and better video displays, and both of these were developed with NASA's help.

CENTRALIZED STORM INFORMATION SYSTEM

The Centralized Storm Information System was developed at our university and Kansas City jointly by NOAA and NASA, and has improved tornado forecasting to the point that at least half of the tornado watches issued by Kansas City verify with a real tornado.

A watch is that a tornado is possible. A warning is that it is actually on the ground. For a watch, you had better be ready to duck. On the other hand, when it is a warning, you had better duck because it is at hand.

This is a significant improvement over the record of a decade ago, and the record still continues to improve. The geosynchronous satellite images and soundings are the key to this remarkable improvement, they have been pioneered by NASA, and now are utilized on a routine basis by NOAA.

Again, tornadoes don't occur at random, but we have better information on a planetary scale in which the tornadoes are imbedded. Obviously, we have better computers and better mathematical models, but the global data to operate these models, especially over the oceans, is provided by both polar and geosynchronous satellites now under the supervision of NOAA.

At some research centers, such as the European Center for Medium-Scale Weather Forecasting, excellent forecasts for three days in advance are now a matter of record. At 6 days out, they are good, they are useful out to 10 days. As yet, we have not achieved that performance in our own national service.

Thus it is a matter of highest priority for the United States to maintain and continue to upgrade the existing system of civilian operating weather measurements obtained from two polar orbiting and two geosynchronous satellites.

SINGLE POLAR ORBITER

I understand the administration's present plans are to reduce the system to a single polar orbiter, albeit with an improved microwave sounder, but with no infrared sounder. Should we lose this single polar orbiter, the result would be catastrophic.

We would lose global coverage of both temperature and moisture structure of the atmosphere, which is needed for weather prediction. We would lose accurate sea surface temperatures, which is important for climate and fishery. We would lose the global cloud cover in both visible and IR; and we would lose data in the polar regions.

The administration has held this position for several years and, thanks to Congress, a two polar orbiter system has prevailed. I strongly urge you to continue to support a two polar orbiter policy.

Now, I will skip a few things, and tell you about some new developments.

New doors have been opened on how clouds control the radiation balance of the Earth. This is very important for climate, and how we deal with it. One of the members of the panel here, Dr. Bretherton, is a pioneer in this study, and he finds these, I am sure, very, very useful.

IMPORTANCE OF OCEAN NOTED

The ocean is very important, and he has alluded to that also, and I needn't dwell on that, except that we need two satellites, which he has mentioned. One is the Topex, which measures the topography of the ocean, sort of finding its highs and lows, so to speak, and it can yield information on the global ocean currents, which redistribute the heat over the planet. The second is the scatterometer which measures the surface winds. The key here is that both are needed at the same time in order to do the task properly. These spacecrafts, already mentioned, have been proposed, and I urge you to support the present schedule.

METHANE MEASUREMENT

No one has talked very much about chemistry, but our progress in infrared interferometric spectroscopy has been no less than fantastic. These instruments can now be carried on new spacecrafts. One can, for example, measure methane to one part in a billion over long pathlengths.

Why this fuss over methane? One methane molecule blocks as much heat from the earth as 10,000 carbon dioxide molecules. So all of the optically active trace gases block almost as much as the $C0_2$, but their rate of growth is much faster, and we will certainly hear more about this.

I will not say anything about remote sensing of land after hearing Mr. Rock because he explained it so well.

MICROWAVE RADIATION

Microwave radiation: We should take advantage of what it can do. It can penetrate clouds. During the last hurricane, we could not observe what was going on below below the clouds. We do have a simple microwave radiometer on our present polar orbiters, and there are plans to put in an advanced microwave sounding unit on polar orbiters, but without infrared. These pass only twice a day overhead, and it would be very, very helpful to have these on the geostationary satellites.

The Europeans are already considering this, and we should try to cooperate with the Europeans to do this, and it would go a long way toward filling the gaps in the data which now limit our ability to model the atmosphere's behavior.

I could go on and on, but I won't do this. There are stacks of documents which describe these opportunities in detail. The space program has advanced our knowledge of the stars and planets. We have to remember that our own Sun is a star, too, and our Earth is a planet, a very precious one. I think we should try very hard to pursue the science, and pursue the activities in the earth sciences since all of these things are interrelated.

In summary, Mr. Chairman, I think interagency cooperation has been very successful. We should continue that, and maybe strengthen that policy in the future.

The second thing I would like to remark is that NASA has put together a good Earth science program. In fact, it leads the world in outlining what is needed for the earth sciences. You have already heard from Dr. Bretherton on that score.

I also think, though, that the Earth program can be put into jeopardy, and this is the thing that concerns me very much, one, by cutbacks in the operational space program to the point where we lose much of the needed capability of the future, and also by the tragic setback in the Challenger Program.

We need to give earth science some priority in the competition with the military for these schedules. In the new STS program, we need to be super-safe, but it does not mean that we have to be super-conservative in what we should try to do.

Thank you.

[The statement and questions and answers follow:]

STATEMENT OF PROF. VERNER E. SUOMI, DIRECTOR, SPACE SCIENCE AND ENGINEERING CENTER, UNIVERSITY OF WISCONSIN

I am Professor Verner E. Suomi, from the University of Wisconsin at Madison, Wisconsin, Professor of Meteorology and Director of the University's Space Science and Engineering Center. I have been closely involved with the weather satellite program from its very beginning, so I can attest to the progress made and give you some idea about future possibilities.

Recently, we all witnessed a great tragedy in the space program. It will take some time to recover from this tragic loss, and at times like these we tend to forget or ignore the triumphs of the program. I want to tell you about some of the triumphs that the space program has contributed to better weather forecasting.

Most of us are familiar with the views of our changing cloud cover as seen on daily TV weather programs. Satellite observations have been with us for 25 years, but only recently have we been able to exploit them routinely and operationally. For example, during the last hurricane season we had superb satellite coverage of hurricanes Elena and Gloria. As a result of the coverage on Elena, millions of citizens about to spend their labor day holiday on the Gulf Coast were kept out of danger despite the erratic behavior of this dangerous storm. As a result, only a few lives were lost in a situation where thousands could have been.

Now the tornado season is upon us, and already we have had timely warnings of these truly violent storms. Most individuals do not have an appreciation of how destructive and powerful they are. In a 1983 storm in Barneveld, Wisconsin, only 20 miles from my home in Madison, the entire town was wiped out. It made the water tower look like the leaning tower of Pisa, and a bumper with license plate still attached was torn from a van and found 26 miles away! I am happy to say, Mr. Chairman, that our ability to forecast these destructive storms during the last several years has improved dramatically thanks to geosynchronous satellites and better video display systems, both developed with NASA's help. The Centralized Storm Information System, developed at Wisconsin and installed at Kansas City jointly by NOAA and NASA, has improved forecasting to the point that at least half the tornado watches issued by Kansas City verify with a real tornado. This is a significant improvement over even a decade ago, and the record still continues to improve. In addition, the more severe the tornado outbreak, the more accurate the prediction. The geosynchronous satellite images and soundings are the key to this remarkable improvement -- both pioneered by NASA in cooperation with NOAA.

Tornadoes do not occur at random, but are embedded in weather of larger scales. On the planetary scale, progress has been impressive. We, of course, have bigger computers and better mathematical models, but the global data to operate these models, especially over the oceans, is provided by both polar and geosynchronous satellites.

At some research centers, such as the European Center for Medium-scale Weather Forecasting, excellent forecasts for three days in advance are now a matter of record. At six days out, they are good, and are useful out to 10 days. As yet, we have not achieved that performance in our own national service.

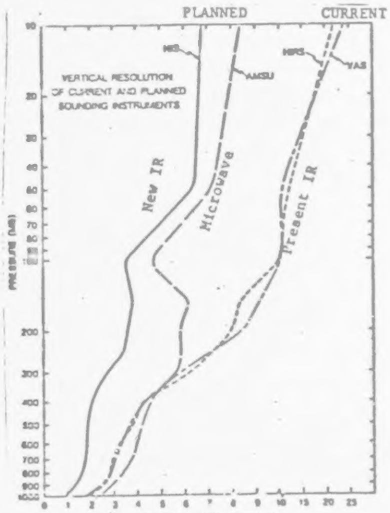
Thus, it is a matter of highest priority for the United States to maintain and continue to upgrade the existing system of civilian operational weather measurements obtained from two polar orbiting and two geosynchronous satellites. I understand the Administration's present plans are to reduce the system to a single polar orbiter, albeit with an improved microwave sounder, but with no infrared sounder. Should we lose this single polar orbiter, the result would be catastrophic. We would lose:

- global coverage of both temperature and moisture structure of the atmosphere;
- accurate sea surface temperatures;
- global cloud cover in both visible and IR;
- data in the polar regions.

The Administration has held this position for several years and, thanks to Congress, a two polar orbiter system has prevailed. I strongly urge you to continue to support a two polar orbiter policy.

We must also keep and improve the IR sounding capabilty, both on polar and geosynchronous meteorological satellites. When there is a clear view, which is the majority of the time, the IR sounder wins on performance hands down. We really need both microwave and IR, since they complement one another well. Instead of eliminating the IR sounder, we should continue to improve it. The knowledge and technology to do this are now available; it's just a matter of doing it. The figure below is a comparison of our present polar orbiter

VERTICAL RESOLUTION OF HIS COMPARED TO OTHER SOUNDERS
(PRECISE THEORETICAL SPECIFICATION)



HIRS instrument and the geo VAS instrument, as well as the planned AMSU and a new high performance system HIS. All IR systems outperform the microwave system in terms of vertical resolution in the lower atmosphere. Good vertical resolution is vital, since it controls our ability to measure the stability of the atmosphere so important for severe weather prediction.

Future Opportunities

1. Observing the ocean. The ocean is the great "heat flywheel" of our climate system. We need to know how it moves and measure the wind forces which cause it to move. Two new spacecraft will allow us to do this: First, Topex which, by measuring the topography of the ocean (finding its hills and valleys, so to speak), can yield the global ocean currents -- a key parameter in the redistribution of heat over the earth for climate. Second is NROSS whose scatterometer will observe the surface winds which drive the ocean currents. Both are needed at the same time in order to do the task properly. These spacecraft are already proposed by NASA, and I urge you to support the present schedule.

2. We need to know the global chemistry. Our progress in infrared interferometric spectroscopy has been no less than fantastic! These instruments can be carried on our new spacecraft. One can, for example, measure methane to one part in a billion over long pathlengths. Why the fuss over methane? One methane molecule blocks as much heat from the earth as 10,000 carbon dioxide molecules. All of the optically active trace gases block almost as much as the CO_2, but their rate of growth is much faster. We need to know more about their sources and sinks.

3. Remote sensing of land surfaces from space of course tells us precisely where things are. But, in addition, with sophisticated analysis, we can tell what is happening on the surface in fields as varied as forestry, geology, hydrology, and glaciology. In fact, with accurate satellite tracking, we know much more about the shape of the earth, its gravity field, and the movement of the giant plates which are the source of earthquakes.

4. Microwave radiation has the advantage that it penetrates clouds. During the last hurricane we could not observe what was going on below the clouds. As already mentioned, we do have a simple microwave radiometer on our present polar orbiters, but these pass overhead only twice a day. NOAA plans to add the Advanced Microwave Sounding unit on polar orbiters, but we need to equip our geostationary satellites with a microwave system as well. Cooperation with the Europeans to do this seems possible. This would go a long way toward filling gaps in the data which now limit our ability to model the atmosphere's behavior. These are all possible with today's technology. The great advantage of a geostationary satellite is that the weather moves, not the satellite.

I could go on and on about the existing possibilities of what we can do. But in order to do these things we need an Earth Observing System, or EOS. EOS does not mean an earth observing satellite, but a system. We must not measure our success by the elegant instruments and spacecraft which orbit the earth. To be sure, these provide much new and highly useful data. But we need the computers, analysis systems, and numerical modelling efforts on the earth to convert this flood of data into information. The apparatus here is just as important as the great new things we can do from space.

There are stacks of documents and plans which describe in detail what is now possible when we look downward. In this short statement I cannot provide a satisfactory overview, let alone give an adequate description of what is possible.

In a manner of speaking, we have the easy job. We know what is possible. We know that it is very useful, and many of us are very anxious to do it. You, on the other hand, have the difficult job. You must take our word that these great things are possible and convince the citizens back home that making the commitment and investment are wise moves. One must convince the hard-pressed farmer in the Midwest that it really makes sense to observe the middle of the equatorial Pacific Ocean as the recent El Nino taught us. We must look beyond our city, county, state, or even our country and press for the global view.

The U.S. space program has advanced our knowledge of the stars and planets. We must remember that our sun is also a star and that the earth is a planet too -- a very precious one to each of us. We want to learn about the future wellbeing of the earth. As the Europeans are saying, "Look downward, look forward." We ought to join them and others throughout the world to better understand our complex but precious earth and how it works.

We must not let our recent tragedy keep us from still more future triumphs.

Thank you, Mr. Chairman, for the opportunity to present my views on how the earth is being studied and can be studied from space.

QUESTION SUBMITTED FOR THE RECORD BY SENATOR ALFONSE M. D'AMATO

FUTURE RESEARCH AND SPACE-RELATED STUDIES

Question: What types of studies have been planned for future shuttle flights, especially those that might not have been initiated without findings from previous studies conducted with the aid of the shuttle?

Answer: Data acquired from the Space Shuttle flights to date have proven to be invaluable to many scientific disciplines, both in terms of learning how to use the Shuttle as an observing platform in the future and in terms of acquiring unprecedented data to help us understand the earth's atmosphere, land surfaces, and the plasma surrounding the planet. A few examples of NASA's experience will illustrate this statement.

The Shuttle Imaging Radars (SIR-A & SIR-B) have demonstrated the potential for active microwave sensing of the earth's land surfaces. While these data have provided detailed images of the geology, surface roughness, and vegetation discrimination, they have stimulated interest in future flights which would include global coverage (polar orbit), multifrequency sensing (L, C, and X-bands), dual polarization, and improved calibration to enable us to study soil moisture, vegetation, surface scattering/reflectance/absorption properties and perhaps biomass.

In the atmospheric science arena, the flight of MAPS (Monitor of Atmospheric Pollution from Space) aboard the Shuttle has proven that an important trace gas such as carbon monoxide (CO) can be measured from space. These results indicate the need to acquire CO measurements throughout the troposphere (as opposed to a single mid-troposphere layer measurement), to broaden geographic coverage to cover the entire globe, and to make repeated measurements over a long term to understand the trend in CO abundance and the relationship of this abundance to other important chemical reactions in the troposphere.

The flight of the ATMOS (Atmospheric Trace Molecules Spectroscopy) Experiment on the Space Shuttle has provided measurements of over 40 species of trace gases (with sensitivities of parts per billion in some cases) over the entire depth of the atmosphere. These measurements have had a bigger impact on the science community than all the balloon aircraft and rocket flights made up to the present time in terms of verifying models and theories, acquiring unprecedented measurements, and proving the value of seven-day long data sets. Even these limited data sets are important when they can be repeated over a long time period to observe possible trends, and they have the added virtue of being calibrated before and after each flight so that sensor performance can be carefully checked.

In the plasma physics arena, past Shuttle flights have demonstrated that the Space Shuttle environment is an excellent one from which to make many measurements. The infrared shuttle glow was found to contaminate IR measurements and has impacted future plans to fly sensitive IR telescopes. The orbiter itself has been shown to discharge itself through plasma interactions with the environment, thus relieving safety concerns that certain experiments (such as tethered payloads) could not be performed. Electron beam experiments have been used to stimulate artificial aurorae which were detected from their radio emissions. This and other findings have stimulated interest in additional experiments which will culminate in space plasma lab flights in 1990/91. Other results include the discovery that if electron beams produced by Shuttle-borne experiments are modulated at radio frequencies, the beam acts as a transmitting antenna, suggesting further communications experiments to explore this phenomenon.

INTERACTIONS BETWEEN OCEANS AND CLIMATE

Senator GARN. Thank you, Doctor.

Doctor Bretherton, you have indicated that Topex will measure ocean height at the same time that Naval Remote Ocean Sensing System, known as NROSS, measures the ocean's response to winds in the atmosphere.

Could you tell the subcommittee what some of the implications of accurately identifying the interaction between the oceans and the climate will be?

Dr. BRETHERTON. Yes. Let me start by explaining a little bit about the role of carbon dioxide in the atmosphere. This behaves in many ways like the glass in a greenhouse. In other words, it lets the incoming sunlight through, but holds back the outgoing heat from the surface. The net effect of increasing carbon dioxide is to warm the surface layers of the planet.

What you are really doing is putting more heat in over and that shows immediately as a warming. The ocean on the other hand is capable of absorbing and storing a great deal of heat. In fact, in order to heat the world by the amount that we are anticipating here, some 2 or 3 degrees centigrade, if in order to do that, we had to heat up all the water in the ocean, the warming that we are talking about would be delayed very substantially by some 100 years or 200 years.

This, obviously, would be a consequence of major importance in our understanding of how the system really functions. However, the ocean circulation isn't quite like that. The heat is being put in at the surface, and one of the first questions we have to ask is through how deep a layer will, in fact, that heat be distributed.

In order to answer that question, we have to examine the laws which describe how the water moves around, how it mixes vertically, and what the impact on all of this of the wind is. That is the nature of the scientific problem that Topex will be addressing in this area.

EFFECTS OF EL NINO

To give another example, a few years ago there was a major climatic fluctuation called the El Nino. During that year, which lasted a little longer than a year, the waters in the eastern Pacific, in the tropical region, were much warmer than they usually. This had disastrous consequences for the fisheries all down the coast of South America and, indeed, all the way up to California where, that summer, the species that were found in coastal waters were completely different, very much poorer, than the usually available.

There were also major changes in the rainfall, not only throughout the Pacific Ocean basin, but extending across to India, and likewise across to Brazil.

In other words, this was a major climatic fluctuation. One of the central question was: Why was the ocean warmer that year? Was the cause or the effect of what was going on in the atmosphere?

To examine this type of question, you need numerical models and good observations, and a lot of basic science, to unravel the processes that are at work. One of the key things you need is observations of the central variables, in this case, the wind, the height of the sea level, and the sea surface temperature.

We did not have those observations on a global basis effectively for the last El Nino, at least not to the accuracy and precision that we need. We do anticipate that with the satellite programs, when a future El Nino event takes place, we will be well positioned to understand better what is going on.

Senator GARN. Thank you, Doctor.

IMPROVEMENTS IN SPECTRAL FINGERPRINTS

Mr. Rock, I appreciated your pictures very graphically describing what you have been able to do. What types of improvements in using spectral fingerprints from space do you anticipate will take place in the next decade? How much do you expect to improve? What will you be able to do?

Mr. ROCK. I think there is a new generation of sensors that will be available on spaceborn platforms in the mid-nineties that will dramatically improve our abilities, our capabilities of detecting damage in vegetation, but also a wide variety of other variables in vegetation.

These sensor systems are referred to as high spectral resolution sensors, and they will provide information rather similar to what that field spectrometer provided. In other words, more information with finer detail, better resolution, and in many cases, the various types of forest response to a variety of stress agents will be subtle in their differences. We will need those high-resolution sensors in order to be able to see those subtle differences.

I would predict that within the next decade, as these new sensor systems develop, we will dramatically improve our abilities to recognize forest decline, insect infestation, drought, a wide variety of things going on on the Earth that influence our vegetation.

Senator GARN. So as pleased as you are with what you have learned to this point, it sounds like this is only the beginning in this area.

Mr. ROCK. I hope so.

Senator GARN. It is really sort of primitive, relatively speaking, to what you will be able to do in the future.

Mr. ROCK. Yes, that is correct.

Senator GARN. Not just from this kind of analysis, but just from both normal photography and our own views of the Earth orbiting, it is quite dramatic what you can see. One of you mentioned the Sahel. Looking at previous photography from the shuttle, how you can document it, it is really rather dramatic, just with normal photography. It is amazing what you can see with proper sun angle on the ocean currents in the wake of ships. For someone, as I said this morning, who had a degree in finance, it was remarkable what a layman could learn from the briefings we had before just with your naked eye, let alone the type of spectral analysis that you are able to do. It is remarkable what you can learn when you get away from the planet and look back at it. You can't here on Earth, or even if you could, as you mentioned to Senator Leahy, none of us would live long enough to even be able to obtain that information.

It was a great eye opener for me, and remarkable what we are able to do.

EUROPEAN WEATHER FORECASTING CENTERS

Dr. Suomi, you indicated the ability of the European weather forecasting centers exceeds the performance of our own national service. Can you explain why?

Dr. SUOMI. One is that they have a better model. They have learned from us, and they have a much more powerful computer power. The third thing is that they have time to get all the global data. They are not asked to give a forecast for the next 6 hours. They can give a 2-day forecast, or a 3-day forecast. It is not necessary for them to give tomorrow's forecast.

Someone has jokingly said that N0AA gets more heck if the forecast isn't out on time than if it is wrong. So from the scientific picture, it is quite the reverse, it had better be right. So the European center is really not an operational group, even though they are dealing with things in an operational timeframe, because they have more time and more data, and they have a bigger computer.

Senator GARN. Does it have anything to do with weather patterns being more predictable, and this is a simplistic statement, but as an example, from the time that I spent in England, I can guess that it rains most of the time without having any sophisticated instrumentation. I can be a much better weather forecaster over there.

Dr. SUOMI. It is true, but on top of that, the distance between England and the United States is shorter than the distance from Japan, for example, to the west coast of the United States. In addition, we have many ocean ships so that the Northern Hemisphere, especially over the United States, over the Atlantic, and in Europe is quite good, and the satellite for the Northern Hemisphere is not so extensive.

However, as you go to the longer range forecast, when you are increasing the length of time, then the global picture is important, not the local picture. For us, the Pacific is very important, and some tests at NASA have shown that the presence of the satellite over the Pacific Ocean is, indeed, important for our weather forecast in the West, in Utah.

Senator GARN. What is the most significant benefit that the space program has provided in your field of study?

GLOBAL VIEW OF EARTH

Dr. SUOMI. I think that it has done two things. One, it provides the global view of the Earth, the atmospheric structure, that is No. 1, and that is due to the polar orbiters and that is why they are important. Also, the geostationary gives us a continuous view of the weather, so we can watch the small-scale events occur.

Most of the kinetic energy for the whole Earth is in the larger scale motion. You would have quite a time convincing one of the residents of Barneveld that there wasn't a lot of kinetic energy in that storm. There was, but it was local. So the energy density for tornadoes scattered all over the world is very low, and it is very difficult to predict. So having the continuous surveillance is very important for the small-scale weather, and that is the kind of weather that affects most of us.

Most of the systems we have now are very helpful for the larger scale, and even for climate. We are counting on that data for climate. So it is essential, Mr. Chairman, that these systems, which are in place now, be maintained over a long period with some stability so that our programs of the future are not jeopardized simply because we would have serious data gaps.

Senator GARN. Topex is being planned as part of a world ocean circulation experiment. What nations are cooperating with us?

TOPEX PROGRAM

Dr. SUOMI. I think that Dr. Bretherton is more familiar with this topic in details, but I believe that France and the United States are cooperating on this program.

Dr. BRETHERTON. On Topex itself is a United States-French program. In the world ocean circulation experiment, it is still in the planning stages, and there is major participation from, aside from the United States and Canada, a number of countries in Europe, France, Germany, the United Kingdom, Italy, Japan.

There has been a lot of interest expressed by a number of countries in the Southern Hemisphere and the tropics, but they are not yet to the point where there are actually being commitments made.

Senator GARN. Senator Lautenberg.

Senator LAUTENBERG. Thank you, Mr. Chairman.

First, I must compliment you on these hearings. The one session that we had this morning was very interesting to bring into focus some of the benefits of our space ventures and the investments that we have been making. All too often, we kind of narrow our perspective on these things, and we don't realize what is taking place because some of these things are rather esoteric to the average human being. Your example about the Midwestern farmer, it is hard to understand why we have got to be doing research on weather when, in fact, he has a crop to plant this spring or this fall, and can't he get the means. It does take a concerted effort to keep all of these things going.

Mr. Chairman, I think that these hearings are excellent, and I look forward to the continuation of them. Thank you for the opportunity to participate.

Those photographs are astounding. I know the area, not as well as Senator Leahy, but I am interested in mountains, and streams, and so forth. I have hiked up in the Green Mountains, the Adirondacks, and those places.

I want to get some information on the record to make sure that the things that we are doing are consistent with what our needs are nationally. You fellows are in somewhat the unenviable position of having folks around here make decisions that affect the long term well-being of mankind, and that is not always an easy sell, especially when the budgetary crunch is applied.

So we will, just for the record, review some of these things, and hopefully expand the public knowledge of what it is that we are doing, so that as we plan our budget commitments there is broader understanding and support for them.

UTILIZATION OF LANDSAT-PROVIDED INFORMATION

Mr. Mack, the information provided by Landsat, how has it been utilized?

Mr. MACK. The information is being stored in the environmental research facility in Sioux Falls, SD, and from there, we will be making the data available to numerous portions of the private sector.

Senator LAUTENBERG. We are building this huge data base; is that correct?

Mr. MACK. That is correct.

Senator LAUTENBERG. How might it be used, to just kind of put it into perspective?

Mr. MACK. I am not totally familiar with the system as it is, having only been here for a short period of time. If I might, though, ask Dr. Bill Bishop, who is our Acting Assistant Administrator for Satellites.

Senator LAUTENBERG. Some examples of the usage of this information that we have gathered. It might be used commercially.

Dr. BISHOP. Senator Lautenberg, I will be happy to give you a few examples.

We have heard of a research example from Mr. Rock today, and I will not recite that. Let me give you a few potential commercial examples.

We know that a number of oil companies use the data in their exploration activities. They do this in a proprietary way, and they have done it with some success, we are told.

We also know that some of the research community have verified that sort of result. So the Landsat imagery is useful for exploration for oil. It is also useful for exploration for minerals. By comparing the bands, one can actually tell that certain mineral-rich clays exist in areas, and identify them quite clearly.

We also know that the Department of Agriculture and a number of private firms use them for assessing crops, much in the way Mr. Rock explained that we assess forests.

Those are just three examples.

Senator LAUTENBERG. So there are current and practical purposes to the Landsat system that are of value to the Nation, you would obviously concur.

Since September 1985, a private company has taken over the responsibility for operating the Landsat system, and for building and launching two follow-on satellites. In return, the company gets to try to market data and establish that land remote sensing can be a commercially viable enterprise.

CANCELLATION OF LANDSAT CONTRACTS

The contract called for Government payments of $260 million, of which $125 million has already been spent, and $97 million is supposed to be spent in fiscal year 1987. Now the administration proposes no further funding and it intends to abrogate the contract.

If they succeed in this, Landsat VI and VII will not be built, and $125 million of Federal money would have been wasted. Does this make sense, Mr. Mack? Do you think that we ought to be cancelling those contracts at this juncture?

Mr. MACK. As you know, Senator, we have implemented an engineering change, implementing an omni-STAR design concept in the Landsat program.

Senator LAUTENBERG. Feel free to call on any colleague. I know that you are new on the assignment. I am still relatively new here, too.

Mr. MACK. I appreciate that. The March 18 modification incorporates an omni-STAR space serviceable platform into the design. This design would be with no additional cost to the Government, and is offering opportunities that we are now exploring.

Looking at potential termination today, if the contract were terminated between now and April 1, the termination costs would probably total about $52 million of the original Landsat commercialization, but the contract with EOSAT contains a clause for termination at the convenience of the Government. We would still have to negotiate the amount of termination costs. But termination is only one of several options that we are discussing with EOSAT.

Senator LAUTENBERG. We can disagree on the amount of money that will be lost because we are cutting the program short.

Dr. Suomi, how do you feel about this problem?

Dr. SUOMI. As I indicated in my testimony, one thing is the need for some stability in the program, particularly as we tackle the climate problem, and also the biosphere, which Mr. Rock talked about, which our previous visitor was so interested in for Vermont.

It is absolutely essential in this whole Earth science program to have some stability in the programs for the simple reason that——

Senator LAUTENBERG. Stability and longevity.

Dr. SUOMI. Yes, longevity, so that we can monitor the changes. We have heard, for example, from Mr. Rock that the damage was actually greater than was first assessed. Part of our problem is what I call, the "don't know squared problem"; that is, we don't know that we don't know. Now we know that we don't know, so we have to do something about it.

Senator LAUTENBERG. Is it important for us as a country to maintain our own land remote sensing system? Is it important to have that as a national resource, do you think?

Dr. SUOMI. As we have heard from representatives from NOAA, when this information is given or used on a commercial basis in a proprietary nature. France with its satellite is having this capability.

Senator LAUTENBERG. Should we rely on them?

Dr. SUOMI. I wouldn't like to.

Senator LAUTENBERG. That makes several of us.

DANGER IN SINGLE POLAR ORBITER

Professor Suomi, what would be the impact on long-range weather forecasting if we scaled back from the two polar orbiters? You did state that in your testimony, I just want to, again, make certain the record is quite clear.

Dr. SUOMI. It is possible to get along with one carefully conceived polar orbiter. It will provide data, to be sure. There is no question that the models show that if you have twice as much data, you improve the forecast. There is no question about that.

However, the real danger in the single polar orbiter is that when it fails, we have nothing, and that is intolerable.

Senator LAUTENBERG. That is a critical factor, but isn't the information assembled in such a fashion that we are getting responses from two orbiters almost simultaneously?

Dr. SUOMI. No. Dr. Bingston, who is in charge of the European Center, that I referred to, has found that there is a significant improvement in prediction when you have data entering into the model more than once or twice a day. He does very much better if it is four times a day. He has pushed this with some interest.

DATA ASSIMILATION PROBLEM

It is called a data assimilation problem. One must not only have the data, but it must be in the model to operate, and having it more frequently gives you fewer holes, so you can do a better job.

In a manner of speaking, our data problem, I have often said, is like negative Swiss cheese, that is, Swiss cheese has a lot of holes in it, and our data situation is even worse than that. In our present data situation, the gaps are like the cheese, and our data like the holes. Anything that we can do to help stamp out gaposis in our data set is very important for climate and for weather also.

Senator LAUTENBERG. So you say that it has a similar appearance, does it have the same odor, that kind of thing? I didn't know what the implication was of the comparison. We will stop with the cheese stories.

What are the differences between the polar orbiters, tell us, and geosynchronous satellites?

Dr. SUOMI. First of all, polar orbiters fly over the poles, so we have a much better measurement of the atmosphere in the polar regions, both in the Southern Hemisphere and in the Northern Hemisphere.

In addition, you can keep track of the extent of the sea ice, which is important for oil rigs in the high latitudes, as well as climate. But probably the most important, the sounder on board, the sounder measures the temperature structure. It is like having a thermometer with an enormously long stem, and you can observe the temperature structure of the atmosphere and the moisture distribution in the atmosphere in the vertical. The vertical distribution is very important because that determines if the weather is going to be unstable and severe, or if it is going to be stable and nice.

The polar orbiter gives us this picture over the whole world, whereas the stationary satellite just looks at the United States, or it looks at the Pacific Ocean. It is true that we get some information from the European Meteosat, and from the Indian Ocean satellite from the Japanese, but these are not equipped with the sophisticated equipment that we have on ours, which allows one to measure the temperature and the moisture structure from geosynchronous altitude.

We would have, without the polar orbiter, a very serious gap in our data base, particularly in the Southern Hemisphere, but sometimes the Southern Hemisphere affects the Northern Hemisphere. So it is a loss, and it gets worse as you try to extend the forecast picture and get into longer range weather prediction and planning.

Senator LAUTENBERG. It also helps us to detect and measure, as we heard so clearly, the environmental pollution that tells us what may be happening with our water, the acid rain problem, and all of this is a central factor in evaluating how extensive the damage is, and perhaps give us some direction.

Dr. SUOMI. To some extent, the weather satellite data has been used along these lines, but of course it is not as dramatic as having the high spectral resolution that you have on the thematic mapper and other instruments on Landsat. The two together tend to collaborate for the simple reason that the Landsat has a repeat cycle, as I recall, every 16 days, whereas the polar orbiter is two times every day, and the geostationary is all day. So it is possible to use them together to help you fill in the gap.

Senator LAUTENBERG. Do I conclude, gentlemen, that there are no shortcuts for developing and gathering this information? It is a tedious process. But the ultimate objective is one that we must pursue.

Dr. BRETHERTON. That is absolutely correct, sir.

Senator LAUTENBERG. I was curious about one other thing.

EUROPEANS UTILIZING BIGGER COMPUTER

You said that the Europeans had a better computer at the core of their operation.

Dr. SUOMI. It is an American computer, but is is a bigger one than we are using.

Senator LAUTENBERG. That kind of shocked me. What are they using that we don't?

Dr. SUOMI. They are using a Cray XMP.

Senator LAUTENBERG. What is our principal computer?

Dr. SUOMI. I don't know what our computer is, but I don't think that it is a Cray. It is a CDC, I believe.

Senator LAUTENBERG. I didn't realize that. At one time we got into a problem with France because we denied a license for our CDC system at that time, our CDC 600, I think it was. The French felt that they needed a defense calculation in their system, and there was a lot of heat generated for many years.

If there is going to be a dependency, I would rather have others depend on us, rather than our depending on them.

Thank you very much.

Senator GARN. Gentlemen, your testimony has been very useful. We thank you very much for fitting us into your schedule. I know that it was done on short notice, but I think your testimony will be very, very helpful to us. Thank you for coming.

SUBCOMMITTEE RECESS

The subcommittee will stand adjourned, and we will reconvene at 10 a.m. tomorrow when we will continue the hearings on the NASA space program accomplishments.

[Whereupon, at 3:32 p.m., Tuesday, March 25, the subcommittee was recessed to reconvene at 10 a.m. Wednesday, March 26.]

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

NASA SPACE PROGRAM

WEDNESDAY, MARCH 26, 1986

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittee met at 10:07 a.m. in room SD–192, Dirksen Senate Office Building, Hon. Jake Garn (chairman) presiding.

Present: Senators Garn, D'Amato, Leahy, and Lautenberg.

INTRINSIC HUMAN VALUES OF SPACE EXPLORATION

OPENING REMARKS

Senator GARN. The subcommittee will come to order.

This morning, we have the third in a series of hearings on the benefits of our Nation's space program. Yesterday, we heard from industry representatives and a panel on environmental and Earth science, in which we reviewed the substantial scientific and economic returns of space exploration and technology.

Yet, these hearings barely scratch the surface of the diverse contributions yielded by our space program, and many more sessions will be necessary to adequately address its universe of tangible and very measurable benefits to those of us here on Earth.

However, in our session this morning, we will attempt to broaden our perspective with testimony on the less definable—but undeniably substantial—intrinsic human values of space exploration.

To present this testimony, we do indeed have a very distinguished panel. We, as politicians, often fool ourselves into believing that we are popular, eloquent, and effective communicators. In the Senate, if any of these traits fail us, we filibuster.

On behalf of the subcommittee, I am honored to welcome Jack Anderson and John Denver who clearly never have this problem. In addition, it is a pleasure to welcome Otho Eskin of the State Department, who will address the international perceptions of our space program, and Barbara Morgan, NASA's teacher-in-space designee.

BARBARA MORGAN, TEACHER-IN-SPACE DESIGNEE

I would like to say about Barbara, I had the opportunity to meet her several months ago, when she was selected in this very room, where we had a reception, both she and Christa did an incredibly good job in training. There are a lot of questions about whether civilians should fly in space or not, and I have made the comment many times that most of the mission specialists are civilian, who chose to work for NASA. Dr. Rhea Seddon, on my flight, is a medical doctor; Jeff Hoffman is an astronomer. People question whether civilians can train adequately.

Barbara and Christa did just as good a job in that training, because I checked. I have lots of spies down there that feed me grapevine information. They are a credit not only to the teaching profession, but to NASA for the way they have performed. There is no doubt in my mind that Barbara will have the opportunity to fly. It is not a question of if, she will. It is just a matter of when. There is no doubt in my mind that she will do a great job when she has that opportunity.

We do welcome each of you today. We look forward to your testimony. Before we turn to you, however, I would like to turn to my distinguished colleague from Vermont, Senator Leahy.

SENATOR LEAHY RECOGNIZES WITNESSES

Senator LEAHY. Thank you, Mr. Chairman.

I, too, would welcome this group here today. It is a distinguished group. This promises to be one of the more interesting hearings we have held.

I am pleased to see my long-time friend, John Denver. We are very happy to have him here.

It is nice to see Jack Anderson again. We hadn't seen him for a while.

Mr. Eskin, and Ms. Morgan, it is good to have you here. I have obviously read about you, Ms. Morgan, and do hope that you will have that opportunity to go into space.

I hear only vicariously how interesting it is to be a civilian in space from distinguished chairman.

Senator GARN. He can hardly stand it anymore, he has heard so much.

Senator LEAHY. He has told me, however, that the special helmet that they made for him to accommodate his particular hairline is waiting for me when I want to go, so I am getting ready to do that.

In this committee, of course, we will ultimately examine the question of just what we will do with the future of the space program, an extraordinarily expensive program. We will have to make the determination of how much this Congress will put into the program; what we will buy; whether we will vote another shuttle; what will be the future of the shuttle program.

Actually, some of the decisions that we will make in the appropriations process in the next year or so will determine what kind of a program we will have for the rest of this century. There is no question that the United States will remain in the space program. There is no question that we will push the frontiers of science and technology as much as we can.

The question will be: What will be the direction and nature of that space program. So what you say here today is valuable to us, as it will be valuable to those who answer some of those particular technical questions.

Our space program, ultimately, is made up of a combination of the technical and of the visionary, the dream of what it can be, and what it should be. This country is solidly in the forefront in space and will remain that way. Our decision will determine not just what our space technology will be, these decisions will also determine what our dream for space will be. I thank you for being here.

Senator GARN. Senator D'Amato.

OPENING REMARKS OF SENATOR D'AMATO

Senator D'AMATO. Mr. Chairman, let me commend you for calling these hearings together at a most appropriate time and for being able to bring together such a distinguished group of witnesses, who will bear testimony to the necessity of moving forward with our space program on many fronts.

Our young people; it is important that we challenge them, their involvement in school, in technology, and in the sciences. Today we will discuss human aspects of our space program in terms of the future and the potential it holds.

Mr. Chairman, I think we all owe you a debt of gratitude for your perspicacity in the face of what might deter others, in terms of lifting up hopes and aspirations, saying very clearly that we have to gather ourselves, our resources, and to move forward, yes, prudently, but to go forward with determination and with hope.

PREPARED STATEMENT

Mr. Chairman, I am only sorry that I have three other hearings, all scheduled at the same time, and I will not be able to stay to listen to our witnesses. With your permission, I would like to have my prepared statement made a part of the hearing record.

I assure the witnesses that I will be reading their testimony, and I publicly would like to thank them for their efforts in giving heart and determination to what our efforts can and should be in the future in terms of space.

Thank you, Mr. Chairman.

Senator GARN. Thank you, Senator.

[The statement follows:]

STATEMENT OF SENATOR D'AMATO

Mr. Chairman, Americans are excited about the many potentials of the space program. As the title of this hearing suggests, there is intrinsic human enthusiasm about space exploration. The perspective of today's panelists holds promise of reassuring our citizenry of the many benefits provided by this program. In particular, the

Space Flight Participant Program is designed to communicate flight activities to the public through educational and public information programs. This program stimulates student interest in science and mathematics, which is vital for continued U.S. technological strength and development. It is anticipated that the shuttle program—when it is restarted—will include space flight participants two to three times a year. I look forward to further developments in this program and other programs included in our U.S. space initiative.

Mr. Chairman, another noteworthy program providing invaluable education to our youth is the Young Astronaut Program. As a supporter of the Young Astronaut Program Medal Act (S. 1952), I am pleased that the Young Astronaut Program is represented at this hearing; it provides many benefits for our youth. The Young Astronaut Program is a national program that has been in existence for about a year; it focuses on the sciences, math, and technological education for elementary and junior high school students. This program has done an outstanding job of increasing our youth's awareness of the sciences by utilizing the excitement of national science activities.

The Young Astronaut Program should be commended for producing diverse classroom curriculum materials for grades 1 through 9 and for sponsoring educational field trips. A national newsletter also has been published by this organization for its member chapters. The Young Astronaut Program has been supported entirely by contributions from the private sector. Its contribution to space exploration is immeasurable. The dedication and commitment of this program, its members, and its leaders deserve congressional recognition for they teach our youth about the exciting science applications in space.

Mr. Chairman, today's panelists, representing the Teacher-in-Space Program, the Young Astronaut Program, and those representing other efforts, have shown a special commitment to our space program. Their first-hand knowledge of the benefits of space exploration is essential as we work toward further development of U.S. space policy.

Thank you, Mr. Chairman.

YOUNG ASTRONAUT COUNCIL

STATEMENT OF JACK ANDERSON, SYNDICATED COLUMNIST, AND FOUNDER AND CHAIRMAN, YOUNG ASTRONAUT COUNCIL

Senator GARN. Our first witness will be Jack Anderson, and I am sure that he is well known through his column. I am not sure, but what is not nearly as well known is his involvement with Young Astronaut Council, of which he is the founder of the program. It is an incredibly good program.

One of the things that I have had an opportunity to do since my flight is to participate in a lot of schools, mostly in Utah and here, but also at a lot of other places around the country as well. I was pleased to see the excitement that glistens in their eyes and, hopefully, we will be using space as a carrot to get them to study science, math, chemistry, engineering, and so on. It has been a remarkable experience.

That is why somebody like Barbara, who is a trained educator, which I am not, could have such a dramatic impact on the school systems of this country once she has experienced that.

Jack is the founder of the Young Astronaut Council, which is of great benefit to the educational systems of this country. I only hope that working with him, over the next 2 or 3 years, I can be part of establishing a Young Astronaut Council chapter in every elementary school in my State.

Jack, we are happy to have you here. We commend you for your work with the Young Astronaut Council.

Mr. ANDERSON. Thank you. I listened to the introduction with grateful embarrassment.

I am now chairman of the Young Astronaut Council, which was established by President Reagan to prepare our children for the 21st century.

YOUNG ASTRONAUTS PASS FIRST TEST

I am proud to report they have passed their first test. It came with sudden fury in the Florida sky. Children across America beheld on television the flaming end of the *Challenger* space shuttle. All on board died in the eternal quest to expand the frontiers of knowledge—of where we came from, who we are, what we can be.

There was special poignancy in the death of a schoolteacher, Christa McAuliffe, who had ventured into space seeking to stir the imaginations of young students. She had hoped to turn them on to a new appreciation of the tough disciplines they must master if they, too, are to explore the universe.

The Young Astronaut Council co-sponsored the teacher-in-space launch and brought Christa McAuliffe's 8-year-old son, Scott, and his third-grade classmates to Florida to watch it. They arrived full of excitement—19 children and 14 adults from Concord, NH—and returned home in shock. They also invited a Young Astronaut from Teaneck, NJ, to share their experience—a dozen black kids who at first romped and laughed, then cried with them.

REACTION OF YOUTH TO "CHALLENGER" TRAGEDY

One Young Astronaut appeared afterward in Newsweek, gazing pensively into space from the spectators' stand. His picture, the magazine reported, "said it all." The caption asked in bold letters, Why? with this text: "Ben Provencal, 9, watches as a classmate's mother soars to her death."

Well, Ben still doesn't fully understand why. But he has plunged with new determination into a study of space. He monitors the television screen intently for news about the *Challenger* and reads everything he can find about space. He also assembled a model shuttle, which he calls Challenger.

Ben Provencal is typical of the other Concord children—typical, too, of Young Astronauts from the Arctic Circle to the Florida Keys. I consulted with eminent child psychiatrists after the tragedy, and they said that children should be encouraged to say how they felt. This advice went out on our electronic network, Astronet, to more than 6,000 chapter leaders. The response from the Young Astronauts was resounding. They felt that Christa McAuliffe was their space teacher, and they were saddened by her violent death. But the tragedy made them all the more determined to explore space.

There was no wilting of spirit, no feeling of futility, no shrinking from the future. With startling maturity, the children seemed to understand that questions will always rise beyond answers, as new starts appear beyond the next on an eternal horizon. They accepted that research has its risks, that risks go with exploration, that progress has a price.

The new generation hasn't lost the spirit that made America great. Yes, our children have the "right stuff."

PETER BILLINGSLEY, SPOKESKID

Peter Billingsley, the child actor and Young Astronauts spokeskid, told a TV interviewer: "If I was asked to go into space, I would still go in spite of the *Challenger* tragedy. I would go now if I had the chance." Here are a few other typical responses selected at random from our mail:

A fifth grader wrote from Kansas City: "I would like to go to all the planets. I wouldn't go to the Sun because that would burn me. But I would go everywhere else."

Listen to this from a 13-year-old Hobbs, NM, girl: "When I saw the explosion, I was stunned and I started crying. I may have not known Christa, but it was just like she was my mom or something, and the explosion happened, and I was saying, 'Oh, my God, Christa McAuliffe was aboard that shuttle.' This day has really put a dent in my career, but I am trying not to let it stop me. I am wanting to be an astronaut."

An Eskimo boy in Mt. Village, AK, may have put it best. "If our ancestors would have been afraid to cross over the ice, we wouldn't be here today."

Here is how an 11-year-old, Dale City, CA, boy expressed his feelings: "If we stop going into space, people everywhere will die a little in their hearts. I want to make sure no silly-thinking adult stops people from being in space."

A 15-year-old boy, calling himself a future astronaut, wrote: "Before the disaster, I only wished to go into space. Now I feel very strong about a decision to 'reach for the stars.'"

There was also this from a 10-year-old Philadelphia boy: "The January 28 tragedy set us back, but it can't hold us back. We all loved Christa McAuliffe because she was a regular American like us."

A classmate, also 10 years old, said the shuttle explosion "felt like it happened to me." Yet he is still willing to "take the place of the seven astronauts who were killed in this accident."

A little girl in Tucson, AZ, was saddened by the shuttle disaster but also worried that "they won't let me go up now."

And a 9-year-old Chicago girl said it all: "*Challenger* was a terrific lady. We must rebuild her again, only better."

The Young Astronaut Council also arranged for the 112 teacher-in-space finalists the death launch. Each one knew he might have been aboard the flawed *Challenger*, yet each told us fiercely that he is ready to take Christa McAuliffe's place on another shuttle. Like their young charges, the teachers, too, are lured by the great unknown, beckoning beyond the horizon.

The youngsters who started school this year will graduate from college in the 21st century—in a fabulous age of exploration, with distant planets within their reach. Our children can lead America into a new era of discovery, achievement and prosperity beyond imagination. Or, they can inherit a second-rate America, unable to cope with its multiplying problems and shrinking resources.

Admittedly, today is a difficult time to be young. Our children have become jaded and bored, beset by harmful diversions and short on emulations to excellence. Yet a free society cannot drive its youth to excellence, they must be inspired.

Every generation should have a dream to inspire it and adventure to ennoble it. Happily, never has circumstance held forth to young people an incentive to rise above themselves such as space now offers. For half a millenium, the spirit of maximum adventure has awaited the dawn of a new age of Columbuses and Magellans. Now, for our children, it is at hand on a scale infinitely more vast.

OBJECTIVE OF YOUNG ASTRONAUTS

Young people are already fascinated by space. To channel that fascination into the hot pursuit of the studies required for the exploration and settlement of other worlds, to make school work less forbidding by dramatizing that it is the key to the universe beyond, to attract students to the tough disciplines that are prerequisites to tackling the challenge of the stars—that is the objective of the Young Astronauts.

President Reagan has established the Young Astronaut Program as a catalyst to stimulate interest in the technologies of tomorrow. The purpose is not necessarily to train future astronauts, nor to transform our youth into scientists. Whatever careers they choose, they will need to understand the terminology and use the tools of the technological age. The purpose is to shake young Americans out of the doldrums and prepare them for the technological challenges.

KIDS ILL PREPARED FOR FUTURE

I regret to report that our kids are now woefully ill prepared for the future. They must master computers, lasers, robots, and microwaves. They must understand advanced math, physics, electronics, and the rest. This will be absolutely essential in the next decade, otherwise they won't be able to operate the everyday equipment.

Yet as the technological challenges have increased, the educational standing of young Americans has fallen. Our schools do not adequately teach the scientific skills that will be needed after graduation.

The teacher who died in the explosion will not give the lessons she had planned to teach from space, but it is fitting that her bold adventure cause us to reflect on the education lag in America that she sought to confront.

There was a time when passionate respect for education seemed to be the hallmark of American life. We were the first people to embrace the goal of free schooling, not just for a privileged elite, but for all the people. The sacrifices made by earlier generations of Americans to get their children educated are legends that are true. The school complexes that today dominate even our smallest towns, flanked by their fleets of yellow buses, are pervasive testimony to a continuing commitment.

But if the commitment is broad, it is also thin—so thin that education in America is today falling dangerously behind that of other advanced nations. We put up the buildings and we hand out diplomas by the millions. But the quality of education has declined. In comparative tests, U.S. students are invariably outscored by students from rival industrial nations. One review of international tests found that American schoolchildren placed last frequently.

This is a competition that we must reenter with a new vigor if we are to keep faith with the American dream. And if we hope to remain the preeminent supplier to the world of sophisticated equipment and to see our children earn the rewards of an advanced economy and to escape the trade balance sheet of an underdeveloped country, we must face some stark facts.

JAPAN REVEALS KEY TO PREEMINENCE

A look at Japan, our principal industrial competitor, reveals the key: What is ardently respected in the home and rigorously taught in the schools translates into superiority on the factory floor and in the marketplaces of the world. In Japan, according to Harvard's Prof. Merry White, "Any worker on the factory floor can be expected to understand statistical material, work from complex graphs and charts, and perform sophisticated mathematical operations." His typical American counterpart cannot do these things.

Mind you, the Japanese don't spend any more money on education than we do, but they take more interest in it. Diane Ravitch, the noted historian of education, gets to the nub of the problem: "respect for education." She cites a study that compares Japanese and American attitudes: "Whereas Japanese parents are quite critical of the quality of their schools, even when they are producing outstanding results, American parents tend to be satisfied, even when their children's schools are ineffectual."

The result is the Japanese schoolchildren go to school 240 days a year, do 2 hours of homework each average day, uniformly take the tougher advanced courses in math, science, and languages, and accept the dictum that hard work pays off. American kids go to school 180 days a year, do an average half-hour's homework a day, avoid the advanced courses in math, science, and foreign languages, and prefer snap courses. The predominant peer group attitude in America is to look for the easy way out and, then, in self-defense, to ridicule academic achievers.

The bottom line is this: At fifth grade level, according to a recent study, the worst Japanese class was ahead of the best American class in math. Further along the line, the average high school graduate in Japan is as well educated as the average college graduate here.

The Europeans, particularly the Germans and the Russians, also outperform American students.

NONCHALANT ATTITUDE TOWARD EDUCATION

Of course, the American population is just an amalgam of all these better-scoring people, so we can't logically blame our genes, and have to look elsewhere for explanations of this calamity. Americans simply have developed a nonchalance about education. They have had such a long stretch of lucky good times in this country that they could get along without pounding the books and feel their kids can, too.

Times have changed since the backwardness of our competitors in the world, the unique plenty of our natural resources and our immunity from the ravages of world wars helped us to an easy superiority in world commerce. This led to the idea that there is an easy way out, that the budget doesn't have to be balanced, that it doesn't matter if Johnny's diploma represents empty courses, half learned.

We must find our way out of this inferiority through slackness, or we will be jolted out of it by lost markets, trade deficits, and national humilitations. Why not draw on our old wisdom, the kind the immigrants had, the kind that still motivates the latest wave of immigrants, the Asians?

TECHNOLOGICAL LEADERSHIP IMPERILED

If the present trend isn't dramatically reversed, the United States could forfeit its technological leadership. Our country relies for its technology on a small scientific elite. In contrast, such rival power as Japan, West Germany, and the Soviet Union are building a broad base. From 70 to 90 percent of their high school graduates are proficient in math and science; scarcely 6 percent of U.S. graduates have achieved the same proficiency. This could pass an invisible sentence on America. There are indications, in fact, that it has already inflicted a degree of paralysis upon the Nation.

Mind you, there is nothing inherently wrong with America's children. They are warm, willing, wonderful human beings. But they stand in mute accusation that some terrible mistake has been made in their education.

Teachers are notoriously underpaid. The best qualified are lured away from the schoolroom by higher paying jobs. Those who remain, in return for their monthly mite, are expected not only to teach, but to maintain discipline, police the halls, and practice child psychology.

All too often, they are expected to provide the upbringing that many children fail to get at home. Yet the training and indoctrination of a new high-tech generation cannot be left to our overburdened schools alone. It must start in the home.

Our best students invariably are new arrival, usually Asian-Americans, who landed on our shores sometimes unable to speak English. Their success in school, educators tell me, can be attributed to their home environment. They come from strong families that respect education.

TECHNOLOGICAL PROGRESS OPPOSED

The rush to the future, meanwhile, is fiercely opposed by many Americans who cling desperately to the present. Like the Luddites of 19th century England, who tried to stop the Industrial Revolution by destroying factories, today's recalcitrants would like to halt the advance into the high-tech age. They are bewildered by the complexities, but most of all, they feat the Technological Revolution will deprive them of their livelihoods and destroy society as they know it. Even many intellectuals are fearful of the future. They produce antiscience novels and movies about computers that whirl out of control and fail-safe devices that fail.

But whether some people like it or not, technological progress cannot be reversed and, just as surely as our grandfathers had to give up the horse and buggy, our children will have to abandon the old ways and adjust to the new. In the end, they will find greater challenges, more productive livelihoods, and an expansion of personal horizons. Hopefully, they will inherit a society glimpsed by Abraham Lincoln 125 years ago, "whose course shall be onward and upward, and which, while the Earth endures, shall not pass away."

AIM OF YOUNG ASTRONAUT PROGRAM

This is the aim, at least, of the Young Astronaut Program. We believe young Americans are not so shrunken from their pioneer stock that they will reject the great adventure awaiting them in outerspace. We hope to stimulate them, to stir their imaginations and, in the process, to encourage them to study the sciences.

An important Young Astronaut objective is to promote "peace through space," to develop a sense of the great immensity of space and, in comparison, the infinitesimal size of the Earth. The Young Astronauts view the Earth as merely an oversized spaceship hurtling through the heavens. Any damage to its parts could endanger its entire human manifest. Already, the Young Astronauts have established ties with Russia's Young Cosmonauts, and more than 40 nations have expressed interest in joining Young Astronaut International.

Historically, it has been discoveries—whether the opening up of new continents or of new vistas of knowledge—that have made progress possible.

Fantastic discoveries await our children if we adults will provide the way.

Senator GARN. Thank you, Mr. Anderson.

[The statement and questions and answers follow:]

STATEMENT OF JACK ANDERSON, SYNDICATED COLUMNIST, AND FOUNDER AND CHAIRMAN, YOUNG ASTRONAUTS COUNCIL

Mr. Chairman:

My name is Jack Anderson. I am chairman of the Young Astronaut Council, which was established by President Reagan to prepare our children for the 21st Century.

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If the present trend isn't dramatically reversed, the United States could forfeit its technological leadership. Our country relies for its technology on a small scientific elite. In contrast, such rival powers as Japan, West Germany and the Soviet Union are building a broad base. From 70 to 90 percent of their high school graduates are proficient in math and science; scarcely six percent of U.S. graduates have achieved the same proficiency. This could pass an invisible sentence on America. There are indications, in fact, that it has already inflicted a degree of paralysis upon the nation.

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The rush into the future, meanwhile, is fiercely opposed by many Americans who cling desperately to the president. Like the Luddites of 19th-Century England who tried to stop the Industrial Revolution by destroying factories, today's recalcitrants would like to halt the advance into the high-tech age. They are bewildered by the complexities; but most of all, they fear the Technological Revolution will deprive them of their livelihoods and destroy society as they know it. Even many intellectuals are fearful of the future; they produce anti-science novels and movies about computers that whirl out of control and fail-safe devices that fail.

But whether some people like it or not, technolgical progress cannot be reversed and, just as surely as our grandfathers had to give up the horse-and-buggy, our children will have to abandon the old ways and adjust to the new. In the end, they will find greater challenges, more productive livelihoods and an expansion of personal horizons. Hopefully, they will inherit a society glimpsed by Abraham Lincoln 125 years ago, "whose course shall be onward and upward, and which, while the earth endures, shall not pass away."

This is the aim at least of the Young Astronaut program. We believe young Americans are not so shrunken from their pioneer stock that they will reject the great adventure awaiting them in outer space. We hope to stimulate them, to stir their imaginations and, in the process, to encourage them to study the sciences.

An important Young Astronaut objective is to promote "Peace Through Space," to develop a sense of the great immensity of space and, in comparison, the infinitesmal size of the earth. The Young Astronauts view the earth as merely an oversize spaceship hurtling through the heavens. Any damage to its parts could endanger its entire human manifest. Already, the Young Astronauts have established ties with Russia's Young Cosmonauts, and more than 40 nations have expressed interest in join Young Astronauts International.

Historically, it has been discoveries -- whether the opening up of new continents or of new vistas of knowledge -- that have made progress possible.

Fantastic discoveries await our children if we adults will provide the way.

QUESTION SUBMITTED BY SENATOR D'AMATO

YOUNG ASTRONAUT COUNCIL

Question. Are there any activities being promoted by the Young Astronaut Council in response to the recent shuttle tragedy, and if so, could you share some of these activities with the committee?

Answer. After the *Challenger* disaster, we consulted eminent psychologists and psychiatrists at Harvard University and the University of Houston. They warned that the spectacle of a teacher blowing up in space could have a searing effect on children and advised that we encourage our Young Astronauts to pour their feelings out.

We immediately communicated this advice to our 6,000 chapter leaders. We reached most of them on our exclusive electronic network, Astronet, which has outlets in 500 major cities. We telephoned chapter leaders in more remote areas, then followed up with a written notice to all chapter leaders.

The response was a flood of letters from Young Astronauts across the country. Many had been traumatized by the tragedy, and they gave vent to their feelings. All of them, without exception, wanted to continue the Young Astronaut Program. Almost all wanted to participate personally in the exploration of space, although a few said they were now afraid to fly in space.

DEPARTMENT OF STATE

STATEMENT OF OTHO E. ESKIN, DIRECTOR OF THE OFFICE OF ADVANCED TECHNOLOGY, DEPARTMENT OF STATE

STATEMENT SUMMARIZED

Senator GARN. Mr. Eskin.

Mr. ESKIN. Thank you, Senator.

With your permission, I have submitted a statement for the record, and if you agree, I will just summarize.

It is hard to exaggerate the importance that the U.S. space program has had on America's role in the world, the vision of ourselves and as other countries see us.

The technology over the last 20 or 30 years has changed the world in a very dramatic way. To cite a few examples: communication satellites that have linked us with instantaneous communication throughout the globe. It is important to us, but it many respects it is even more important to other countries, particularly developing countries, which have come to rely on satellite and space communications.

REMOTE SENSING

Remote sensing is a new area that has only in the last 10 or so years begun to develop. It can be said, I think, that the first planet we want to explore in our solar system is the Earth. Ironically, one of the keys to that exploration is through satellites, through the space program. We are learning an enormous amount about our Earth, about our crops, about forecasting disasters, and, of course, weather which has a major impact not only here, but throughout the world for our farmers, for agricultural industry, and for predicting major disasters related to the weather.

In the future, we can look to the development of whole new industries based on space technology, new pharmaceuticals, new materials, which will depend on microgravity.

We have already begun, through the shuttle program, important developments and research in this area. We look to the future with the development of the space stations. We are establishing whole new industries dependent on microgravity technology.

Beyond that, in a more intangible way, the U.S. space program, beginning 20 or more years ago, leading up to the Apollo Program, the landing on the Moon, the shuttle program, has excited the imagination of not only Americans, but the whole world.

AMERICAN SPACE PROGRAM SHARED BY WORLD

I think that it is no exaggeration to say that most of the people around the world feel that the American space program is in a sense their space program. I served many years abroad, and I was abroad during the early stages of the Apollo Program, and I know from personal experience how excited the people abroad were and now closely they followed every step of the program, and how much they identified with the individuals involved.

This has all made enormous contributions to America's reputation, America's image abroad, an image of high technology, a society aimed at the development of new technologies, and the peaceful uses of outer space.

The world admires what we have done. They admire our skill and our vision. They admire our courage and that of the individual members of the crews, our astronauts, and the whole support group that has created this very exciting development, the space program.

COOPERATIVE PROGRAMS

Beyond that, we have more tangible areas which have been strongly stimulated by the space program, and that is in our partnership with other countries. NASA, specifically, has agreements with about 130 countries. Some are very small, involving exchange of data. Others are very, very complex. I would cite as an example, the Space Lab Agreement with the European Space Agency, a major contribution to science, to the development of technology, but also to our foreign relations.

I don't think that it is any exaggeration to say that these cooperative programs in the space area very directly strengthen our relations with our friends and allies.

I would mention one other example, which is the Foreign Astronaut Program. We have already flown several foreign astronauts, and there are several more that are now in training. At this stage, there is no way that we can predict when the program will resume. From our point of view, we certainly hope that it will resume. This has been an important contribution to our ties, not only with the developed countries, those countries with space programs of their own, but with developing countries who are increasingly becoming aware of the importance to themselves and their economies of the space program.

Our goal, in these programs, is to develop truly international partnerships. I would like to note specifically the aim of developing a space station within a decade. We are now working with more than a dozen countries in the preliminary design stage. Within a year or so, we will be signing agreements with the European members of the European Space Agency, with Japan, with Canada, on the construction of a space station, and ultimately the operation of the space station, where we visualize an international crew permanently in orbit, working together, living together.

I think that we are going to be learning a great deal from this experience on how to develop cooperation with other countries, and how we do this in a new technological era.

Finally, I will just say, from our perspective, I only hope that the United States can live up to its own vision in the space field and its promise. If we fail to do that, we will lose more than just space programs, we will lose an important contribution to our foreign relations as well.

Thank you, Mr. Chairman.

Senator GARN. Thank you very much, Mr. Eskin.

[The statement follows:]

STATEMENT OF OTHO E. ESKIN, DIRECTOR, OFFICE OF ADVANCED TECHNOLOGY, DEPARTMENT OF STATE

Space technology and, in particular, the American space program has affected the lives not only of Americans but of people all over the globe. It has changed the way people communicate, it has vastly increased our knowledge of the earth - how weather is formed, changes in vegetation, where minerals are located - and it has allowed mankind to take the first tentative steps beyond our planet to explore the universe. I would like to mention briefly some of the major developments in the U.S. space program over the last few years and the contributions this program has had internationally.

Remote Sensing

Remote sensing of the earth from space satellites began in 1972 with the deployment of Landsat-1, the first of five such U.S. satellites to date. Remote sensing itself is the identification of objects -- be they fields of crops, land and topographic features, water, or man-made objects such as buildings, cities, and park-lands, -- at a great distance through detection by sensitive sensors of the emitted or reflected energy of such objects. With a camera, objects are captured on sensitive film. With a remote sensing scanner, like those aboard our Landsats reflected energy is picked up by sensitive devices and sent back to an earth station not as film, but rather as energy in the form of digital data captured on tape for conversion and detailed correction into images by computers.

Space-based earth remote sensing has proved to be an invaluable tool for certain kinds of agricultural assessments, mineral resources detection, analyses of demographic patterns and changes, detection of potential natural disasters (such as the amount of snowpack in mountainous regions based on the intensity of reflectance), etc.

Since 1972, a world-wide user community for Landsat data has developed, spurred by the U.S. policy and practice of providing Landsat data on an open, equal, non-discriminatory basis to all users. The value of Landsat data, and the openness of our distribution policy, has led to routine use of this system by a variety of economic interests and scientific disciplines and has enhanced the U.S. image as a responsible and beneficent international space partner.

Communications

Among the most dramatic developments in the use of space technology has been the great expansion in communications satellites. We have come to take for granted a technology which only a few years ago would have seemed visionary. We use communications satellites for live television coverage and long distance telephone and computer communications. For many developing countries, particularly those with large masses or consisting of extensive archipelagoes, satellites are essential for virtually all long-distance communications. As a result of the development of communication satellite technology, the world is now tied more closely than ever before by a network of almost instantaneous communications. Our awareness of events throughout the world -- terrorist acts, wars, natural disasters -- has changed forever the way nations deal with one another.

Search and Rescue (COSPAS-SARSAT)

COSPAS/SARSAT is a space-satellite global search and rescue system in which Soviet and U.S. satellites, equipped with French and Canadian transponders, provide an interoperable signal system capable of locating aircraft and ships in distress with remarkable precision. Over 500 lives have been saved since COSPAS/SARSAT began in 1979. Of perhaps equal importance, it has offered the Soviets and the West a mutually beneficial means of cooperating in peaceful uses of outer space.

Weather Satellites

Since 1960, the U.S. has maintained both the technological and policy lead in the acquisition and dissemination of vital, time-critical weather satellite data. U.S. polar orbiting meteorological satellites provide cloud images 2 to 4 times a day to any location on earth with access to a ground station. Data is open and available to all at no cost. Additional technical information from both orbiting and geo-stationary satellites is available to the public via real-time ground receivers and through the World Meteorological Organization's communications network and archives and is the basis for daily TV weather reporting.

The value of weather satellite information is beyond estimation. At any given instant it is being used by fishermen in the South China Sea and oil tankers in the Bering Sea; ski slopes operators of Colorado and sea captains monitoring icebergs of the North Atlantic; ranchers on the Argentine Pampas and farmers in Ethiopia. Typhoons are tracked in the equatorial Pacific, and severe thunderstorms are closely monitored for tornadoes in Oklahoma. While a medical researcher in India plots weather patterns affecting the spread of disease, you may plan your weekend trip to the beach -- or simply try to outguess the weather forecast for Washington's rush hour traffic tomorrow morning. This is but a glimpse of the often taken-for-granted revolution in weather applications which benefits humanity and which has been spawned by U.S. satellites obedient observations of the earth's weather over the last 26 years.

The Promise of Commercialization

There is increasing awareness overseas as well as in this country that space is not only a frontier for exploration but also has commercial value. It is not surprising that much of the expansion in foreign space programs over the past decade has focussed on areas of potential commercial benefit, such as communications, launch vehicle development, remote sensing, and materials processing. A number of countries, including some in the developing world, now have their own communications satellites. Europe, with its Ariane expendable launch vehicle system, already competes vigorously with the Space Shuttle for launch service business, and Japan and China are entering the market. France's SPOT-1 and the newly privatized U.S. firm, EOSAT, are beginning a healthy competition in the land remote sensing field.

A new area of commercial use of space with great potential benefits for mankind is materials processing in zero gravity. Research has already begun on the Shuttle and we hope for major activities on board the Space Station. Micro-gravity offers improvement in many existing production techniques and opens doors to new products. In space, materials can be separated to high degrees of purity (for pharmaceuticals); structural composition and density will be uniform (for ceramics and metals); exacting shapes and sizes are possible without gravity (for near-perfect spheres); and crystalline growth is not hampered by deformity. We expect that these processes will develop new products and ultimately a whole new industry.

The Space Shuttle

Next to the decision to put a man on the moon, the 1972 approval to proceed to develop the Space Transportation System with its manned orbiting Shuttle was perhaps the most forward-looking technological decision in the U.S. space program. The Shuttle orbiter was designed to conduct space missions in an entirely new mode. Not only was it to be a manned space vehicle; it would carry heavy (60,000 pounds) payloads to low earth orbit, or launch satellites and revisit them at a later date. The Shuttle crew could do construction, docking, repairs, check outs, carry out scientific observations and experiments retrieve and repair satellites or return them safely to earth. Most importantly, the Shuttle was reuseable -- like an airplane it could land on a runway and be launched again after reloading.

Although many program and technical problems beset this endeavor, in April 1981 the Columbia orbiter was launched -- the first time man had ever flown into space and returned in the same craft. The shuttle was a true spaceship. This was the leading edge of space technology.

The ability to carry man into space and support experimentation there for several days is the truly unique capability of the Shuttle. Despite the importance of cargo carrying capability, it is the presence of man in the Shuttle which is the centerpiece of the STS and which is absolutely essential to national space leadership.

Foreign Astronauts

Our international partners without exception place great importance on participating in the Shuttle program with their own astronauts. Canada, France, Saudi-Arabia, Germany, the Netherlands and Mexico already have representatives in the elite corps of Shuttle Astronauts. India, Indonesia and Great Britain plan on having their astronauts take part in future flights as do Japan, Brazil, and China.

The loss of the Challenger has raised major questions relating to the resumption of Shuttle flights and this of course will affect participation by foreign astronauts. Resumption of flight opportunities flights for foreign representatives is important to achieving our international space goals, affirming U.S. space leadership, and maintaining close cooperation in space with our friends and allies. We all need to continue to gain valuable experience in working together in space, so that we will be prepared for the truly international crews of the Space Station.

The Space Station

In his State of the Union message in January 1984, President Reagan directed NASA to develop a permanently manned Space Station within a decade and to invite international participation in the project. Japan, Canada and the members of the European Space Agency accepted the President's invititation and last year signed memoranda of understanding with NASA governing participation in the design phase of the project. Japan plans to build a multipurpose facility composed of a pressurized laboratory module, an exposed platform, and a logistics module, with an estimated cost of $1 billion. Canada will develop a mobile servicing facility that will play a major role in assembling and servicing the Space Station, at a cost of more than $0.5 billion. NASA and the European Space Agency are still discussing the elements to be developed by Europe. We anticipate that these will include a polar orbiting platform and a laboratory module. The cost will be roughly $2 billion.

The State Department and NASA will shortly begin negotiating agreements with each of the international partners governing their participation in the development, operation, and utilization of the Space Station. Since the Space Station is a huge, multi-billion dollar project that will last for at least three decades, the cooperative arrangements among the partners promise to be extraordinarily complex. We will have to agree on such questions as how to allocate management responsibility, how to share operational costs and utilization, liability and technology transfer. We also will need to reach agreement with our partners on registration and jurisdiction and control of the Space Station's various components and on the legal regime on board the station.

International Space Cooperation

Since the early years of its space program, the United States has carried out an active program of international cooperation. The National Aeronautics and Space Act states that one goal of the U.S. civil space program is to cooperate with other nations in the peaceful uses of space, thus sharing the benefits of mutual, cooperative space activities. We have cooperative agreements with more than 130 other nations, ranging from joint development programs to data exchanges. A major example of such a cooperative program was the Spacelab developed by the members of the European Space Agency at a cost of over one billion dollars.

The U.S. space program has yielded important foreign policy dividends to the United States. There have been many immediate practical benefits. Cooperation with other nations has strengthened our overall relations with key allies and has permitted NASA to reduce mission costs and gain valuable access to foreign scientific and technological expertise. Beyond that there have also been intangible benefits. The world's perception of U.S. technological leadership has been greatly enhanced. The U.S. space program -- particularly our man-in-space exploits -- has earned us good will and respect around the world. This good will and respect is impossible to measure, yet is undeniably real.

The reaction across the world to the loss of the Challenger gives us a clear idea of the international attitude toward the U.S. space program. Messages from the capitals of the world, its leaders, its explorers, its authors, its storekeepers, laborers, farmers and students poured into our Embassies. Citizens and leaders alike signed books of condolence; the foreign media were filled with stories and editorials on the U.S. space program, the Challenger, and the astronaunts. One statement summarizes this out pouring: "I was stunned upon receiving the news of the loss of the space shuttle Challenger and her crew. They belonged to the world; they belonged to all of us."

The long-term effect of the Space Shuttle Challenger accident on U.S. foreign policy interest will depend on how quickly we react. A quick recovery will be seen as a sign of U.S. strength and confidence. Failure to move quickly to reestablish a strong, reliable space program, on the other hand would weaken U.S. leadership in space at a time when the Soviet Union is moving ahead with an ambitious space program and Europe and Japan are also developing their independent space capabilities.

TEACHER-IN-SPACE DESIGNEE

STATEMENT OF BARBARA RADDING MORGAN, TEACHER-IN-SPACE DESIGNEE

MESSAGE FROM CHILDREN

Senator GARN. Barbara, we are very happy to have you with us today. If you would like to proceed.

Ms. MORGAN. Thank you for your kind comments. I thank you for asking me to share some of my thoughts with you today.

I come to you on behalf of the people of the future. Right now, these people are preparing to take our places. They are watching us from the classrooms and from the schoolyards. They are our children and they send you this message. They tell me to tell you one thing: Go for it.

They say to you: Show us what our teachers are teaching us—that mistakes are lessons to learn from, and that tragedy is a heavy door that we can open if we are strong.

They say: Please hold that door open until we get there.

Lately, I have received over 150 letters a week and I have talked with students from kindergarten through the 12th grade all across the country. Last week, I talked with a group of 1,000 teachers in New Orleans. I have more requests for speaking engagements than I can ever fill.

The other eight teacher-in-space finalists and the 104 semifinalists report the same experience. Students and teachers ask us questions about the accident. They feel very sad, especially for the families. But then their questions go on to to space exploration. The time is up before all of the questions can be asked.

They want to know what it is to be weightless. What does the food taste like? What are the different jobs people do? My favorite question is: How can I get involved?

ERIN GARNER, FIFTH GRADER

A fifth grader named Erin Garner wrote to say:

> I think it is worth the risk to go somewhere new. I think this because if we don't take the risk, I think our future is at stake. It has taken us years to send life into space and if we give it up now, it would like time stands still. If I had a chance to go up into space, I would.

That is the voice of the future speaking.

It is a brave world to have such people such as Erin Garner in it. We can't disappoint Erin through a lack of resolve or through lack of clear thinking. Erin should have her chance to live and work in space.

Erin and millions of her fellow-students now share a great personal feeling of participation in our space program. They see the exploration of space as the Nation's business and as our common goal in future. As we all know, in a society as diverse as ours, a common goal is an uncommon thing. The rewards we receive from working and exploring and learning together are great, and the participation we share with our children is invaluable.

Christa McAuliffe showed children that space is for them. She showed us that space is for everyone. As a teacher, Christa knew that we teach best by showing and sharing than we do by telling. She knew that we learn best by doing. Through space exploration, we are learning by doing. Through manned space exploration, we are learning by sharing. We are setting examples for our children. The universe is our classroom.

So on behalf of students and teachers, I say to you: Go for it. Help our space program and our Nation's education move forward so that our students' future is as bright as they see it.

Thank you very much.

SCHOOL APPEARANCES OF SENATOR GARN

Senator GARN. Thank you, Barbara. How beautifully said. I know what you speak about in the schools, not being an educator myself, I don't know that I have ever had a more satisfying experience in my life than being in the schools in the last year, which is a role that I did not anticipate. I am sorry that the Senate interferes with my being in the schools, I would like to spend a lot more time there.

The look in those children's eyes, to see that excitement, that message you relayed about, "Go for it," it is there. I am going to get some of these Flat Earth Society members that I have been debating on manned versus unmanned flight, I am going to send the kids to debate them, they will really demolish those Ph.D.'s, they really will. They will just take them apart, because they won't have the answers that those kids do about why they want to be in space.

Thank you very much.

[The statement and question and answer follow:]

STATEMENT OF BARBARA RADDING MORGAN, TEACHER-IN-SPACE DESIGNEE

Mr. Chairman and distinguished members of the subcommittee, thank you for asking me to share some of my thoughts with you today.

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A fifth grader named Erin Garner wrote to say, "I think it is worth the risk to go somewhere new. I think this because, if we don't take the risk, I think our future is at stake."

"It has taken us years to send life into space," Erin continued, "and, if we give up now, it would be like time stands still. If I had a chance to go up into space, I would."

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And so, on behalf of students and teacher, I say to you: Go for it. Help our space program and our Nation's education move forward so that our students' future is as bright as they see it.

Thank you very much. I'd be pleased to answer any questions you and members of the subcommittee may have.

QUESTION SUBMITTED BY SENATOR D'AMATO

TEACHER IN SPACE PROGRAM

Question. The Teacher in Space Program was designed for several purposes, including the promotion of sciences in our Nation's schools. Do you believe that teachers and other citizens are still willing to partake in the Space Flight Participants Program?

Answer. Yes; absolutely. I know that teachers and other citizens are still willing to partake in the Space Flight Participants Program. Everywhere I go, people tell me they envy me my opportunity. They tell me they would gladly trade places with me. People see the Space Flight Participants Program as the true opening up of our space frontier to everyone.

STATEMENT OF JOHN DENVER, INTERNATIONAL ENTERTAINER, SINGER, AND ACTOR

INTRODUCTORY REMARKS

Senator GARN. Our next witness is one who is known to absolutely everybody all over the world, recognized wherever he goes. I have long admired John Denver, but I must tell one story about him, for the record, I have told it every other place lately, to show you how popular he is.

In 1974, he came to Salt Lake City to do a fund raising event for my opponent, when I first ran for the Senate. It was very, very successful, it raised a lot of money for my opponent. Two of the young ladies in the audience, a 15-year old girl, and a 13-year old, were my daughters who bought tickets to go to a John Denver concert, and help support my opponent against me. But I have forgiven him for that. [Laughter.]

What most of you don't know about him, and which I have only learned in the last month—I had met him many years ago, which he probably doesn't remember, at a reception. Just "Hi, how are you." But I don't know that I have ever met an entertainer of his fame and notoriety, who is such an incredibly decent human being.

I have had the opportunity over the last month to talk to him about a lot of different things. We have explored each other's philosophies. I think for somebody as famous as he is, and as wealthy—boy, do I envy his Lear Jet, but that is another story for another day. To be in his position and have both feet firmly on the ground, and be such a decent human being, caring about people, about hunger, and war, and peace. It is unusual.

John, I cannot tell you how much I admire you for those human qualities that you have. As great as your singing and music ability is, I think your human qualities are even greater.

INVOLVEMENT IN SPACE PROGRAM

But most of you don't know of his involvement in the space program, and how he has been an advocate for a long, long time. As a matter of fact, just as an indication of his involvement with NASA, he was awarded the NASA public service medal for distinguished public service in September 1985. That award recognized 15 years of involvement with NASA's activities and programs. This is only the second time in the history of the award that it has been given to an entertainer. Normally, it is given to engineers and design people. So it is an especially great recognition for him.

He is also the originator of the idea that civilians ought to go in space. I will say, for the record, too, he has my support. When we start flying again, I certainly would recommend to NASA that John go. If anybody deserves it, any civilian in this country, for 15 years of dedicated work to the space program of this country, he does.

John, we are honored that you would be here. I didn't want to embarrass you, but I did want to let the people know, for the record and publicly, what you do beyond your singing talent.

ADDITIONAL INTRODUCTORY REMARKS OF SENATOR LEAHY

Senator LEAHY. Mr. Chairman, if I may continue the embarrassment of John.

We Catholics would say that we are leading up to his cannonization of him. When I become Pope, John, I will see to it.

Senator LAUTENBERG. I didn't know that you wanted to be Pope John. [Laughter.]

Senator LEAHY. You couldn't let that one get by, could you, Frank.

I have known John just about all the time I have been in the Senate. We had a mutual and very, very dear friend in Harry Chapin, the folksinger, who introduced us. In the Senate, you meet a lot of people. Some you meet because you meet them in your business. Others you meet because you really like them. One of the ways that I have really judged people I meet, whether in the entertainment world or the political world, is how they react with my own children.

John has known our three children, really, from the time they were little, and he has watched them grow up. There has never been a time when we have been together and the kids have been around, that he hasn't taken the time to spend time with them, ask them how they are doing, and what is up, and so on. It has been a special treat in that regard. I think that it is a mark of John, when he takes time with our children.

My daughter still remembers the time a couple of years ago when she was here as a page, and she was given what she thought was the greatest chore of her life, to spend part of a day escorting John around the Capitol. She said to him, "John, do you know that today is National Hug Day." He said, "I hadn't heard about that one, Alicia, but it sounds great to me." He gave her a big hug, and she was walking on air for about a week after. Then, she said, "Do you suppose John will be upset that I lied about there not really being a National Hug Day," and I still can't get over it.

Anyway, I am delighted you are here.

Senator GARN. Just one more story, John, and we will stop embarrassing you, and let you testify.

Senator LEAHY. These are very serious hearings, we want everybody to know that.

Senator LAUTENBERG. I think the witnesses' testimony so far has been excellent. [Laughter.]

Senator GARN. Following up on what Pat said about his children, last night, my family and I had dinner with John. My little 10-month old granddaughter was there, and it got rather late, after we had been down at the Smithsonian. Do you know who held our little 10-month-old granddaughter most of the time, John. She was being a little bit fussy, rather good for that late at night, but he was singing to her gently. She liked his voice. Even at 10 months, she was quieter for him than anybody else at the table.

John, please proceed.

TESTIMONY OF JOHN DENVER

Mr. DENVER. Thank you very much, Mr. Chairman. Thank you for those very kind thoughts.

Senator Leahy, you also, and members of the subcommittee.

I find, when I come to Washington, I am not only pleased to be here this morning, I consider this a privilege. It is very moving to me that in our society, in our great country, we have the opportunity to express our opinions, to ask our questions, to articulate our visions, not only in public or in print, but in front of the leaders of our great Nation. It is a privilege for me to have this opportunity today.

I am especially pleased to address what you call the intrinsic human values of space exploration. I believe very strongly that your use of the word "intrinsic" is appropriate when we talk about all the many things that are involved in mankind's efforts to explore the heavens, and beyond. The word calls our attention to those attributes that are a part of something by their very nature.

EXPLORATION OF SPACE

By its very nature, the exploration of space is an expression of mankind, a statement about the sort of human beings we are, and how we care about understanding ourselves, and our place in the universe.

From the beginnings of history, mankind has sought to explore beyond the place he found himself living. Civilization fanned out, and eventually spanned the globe as a result of people searching beyond their horizon. It was in their nature, as curious human beings, hungry for knowledge and eager to overcome the challenges and obstacles to their search, whether they were unfordable rivers, storm-tossed seas, impassable mountain ranges, or ignorance and fear. No obstacle has yet proven too great for the determined efforts of mankind to expand its horizons.

Though the cost has been high throughout history in wealth and resources and, yes, even in human lives, still mankind has pressed on. The search has continued. We have met and mastered the challenges and faced those that rose up to take their place. It will always be so. It must always be so. For that is what is unique about our species, above all others. It is that indomitable will that ennobles us, and pits us against tests that for us to reach beyond ourselves, and to refuse to accept as a premise that we cannot achieve what we can conceive and believe.

All of us here today, in this room, in this city, throughout the world, are the beneficiaries of the advances made by every single individual since the dawn of civilization. None of the technology and scientific excellence that we have today just appeared one day.

HISTORY OF FLIGHT

We didn't just suddenly start to fly at Kitty Hawk, with no preparation, no history, or experimentation, no record of past attempts, no lost lives.

Wilbur and Orville Wright were blessed with an insight that helped to take literally centuries of thought and dreams of flight, and find that crucial breakthrough, that delicate balance of mass and velocity and aerodynamic lift that let them for just a few moments, at first, "to slip the surly bonds of Earth," as John Gillespie McGhie wrote in his famous poem.

The pioneers of flight that followed the Wright brothers built on what had been learned at Kitty Hawk. Each successive breakthrough was an expansion of the horizons established by its predecessor, right up until April 12, 1981, when *Columbia's* maiden voyage brought the concept of flight to its ultimate expression.

One day, new capabilities, growing out of our shuttle experience, will lead to further developments that we can only guess about today if we follow the examples of those who went before us; if we face and accept the challenges and commit ourselves to meeting them, and moving on.

AMERICAN PEOPLE FAVOR CONTINUATION OF SPACE PROGRAM

The American people know that. They know of the intrinsic value of our space program. Just look at the latest Gallup poll, taken 2 weeks ago. When asked if America's shuttle flights should continue, in spite of the tragedy that struck down *Challenger*, and her brave and special crew, 80 percent—80 percent said, yes. Yes; let's fly again. That was their response even after millions of them watched that terrible day, and have listened day after day after day as the reports of the investigation and speculation about what happened and why have seemed to raise doubts about NASA and our Nation's ability to find the problem, fix it, and get moving again.

Even after that, 79 percent said that they had either a great deal or a fair amount of confidence in NASA's ability to prevent such an accident from happening again. Only 19 percent have either not very much confidence or no confidence at all in NASA's ability to prevent a future accident.

When asked about whether or not civilian astronauts, such as journalists, politicians, and schoolteachers should fly on future shuttle flights, nearly 70 percent said, yes, they should. It occurs to me that if the question had included entertainers with blond hair from the Rocky Mountains, the numbers might have been even greater. [Laughter.]

Senator GARN. They might have been less if they had taken politicians out, too. [Laughter.]

Mr. DENVER. In all seriousness, that sort of expression of the public is based on the subject matter of this hearing this morning—the intrinsic value of space exploration. If you asked 80 percent of the people of America what were their specific reasons for saying that we should keep flying, how many do you think would describe a specific payload, or satellite, or a specific mission, and say, "There, that's why." Not very many. More likely, they will say something like, "Because it is important to us," or "It is something that we have to do." Like the gentleman who was asked why he climbed mountains, he said, "Because it is there."

They may not be able to tell you why, but they know that it is so. They feel it, and they dream it.

"THE DREAM IS ALIVE"

Last night, for the fourth time, I had the chance to see the film, "The Dream Is Alive," at the Air and Space Museum. It was still breathtaking, it was still inspiring, and it was still thrilling.

The dream is alive, Mr. Chairman, and you know that better than most of us because you have lived a part of it.

Even more importantly, for those who may have the chance to live that dream, are the benefits that come to all mankind because the dream is alive, and because we are doing the things that make it a reality.

You had two sessions of hearing yesterday that helped remind us of those benefits. The things industry and science and medicine have gained from 25 years of space exploration are almost impossible to catalog. As I believe you said in your opening statement, Senator Garn, those hearings only represented the very tip of the iceberg. It would be impossible in 2 days to describe every application of technology and expertise and intelligence that has come out of the space program and how they benefit all of mankind.

I commend you for asking us to stop and think about it, though, and to remember that part of the intrinsic value of space exploration is the way it fosters innovation and excellence in fields that have no direct relationship to space flight, and yet directly and materially affect all of our lives and give us tools that we can use to meet the challenges of disease, hunger, and misuse of our planet's natural resources.

VALUE OF SPACE PROGRAM

As you in the Congress look at budgets, as you have to, and make hard choices, as you have to, how do you weigh the value of those tools that have been unintentional gifts to mankind from the space program?

How do you measure the value of lives saved, or of lives improved?

How do you put a value on rapid diagnosis and treatment of previously fatal diseases or conditions with devices that have come from space technology?

I don't know how you place a value on human life and human progress. It is a very broad concept and difficult to quantify. But it is there, and I believe that the American people have demonstrated that they understand that intrinsic value of the space program by voicing their support for it without even knowing the results of any kind of cost-benefit analysis that could put a dollar figure on the value of the benefits from space exploration.

I am here to echo the voice of the people across this land, as they begin to stand and be counted in favor of the continuation of the greatest human endeavor mankind has ever undertaken. I am inspired by their enthusiasm, as I hear it expressed everywhere I go. I believe that the Congress and the administration should listen to that overwhelming vote of confidence.

TURNING TRAGEDY INTO TRIUMPH

The space program was hurt deeply by the loss of *Challenger* and her valiant crew. Many of us felt that loss even more personally because of our close association with NASA over the years, as I know you did, Senator. We still grieve in our hearts for the loss of the crew, and we are concerned about NASA's recovery and return to space flight. But as one astronaut said at a memorial for the crew in Huntsville, "We can turn this tragedy into triumph."

We can let it remind us of our humanity and of our imperfection, and our vulnerability, but we can also let it prompt us to the creation of an even better, even more dedicated and committed space program than we have ever seen. For we cannot honor the lives that were lost on *Challenger* without honoring the things for which they lived. Without perfecting as far as we can the program for which they died, and without expanding those horizons beyond which the *Challenger* seven have soared.

Mr. Chairman, that completes my prepared testimony. I would like, with your permission, to add a few comments, if I may.

Senator GARN. You certainly can.

JOHN DENVER AS CATALYST OF CIVILIAN SPACE PROGRAM

Mr. DENVER. As you mentioned earlier, sir, I feel responsible as a catalyst for the whole civilian space program getting started. A little over 3 years ago, I called James Beggs, who was the Administrative Director of NASA. I said:

> Mr. Beggs, I believe that NASA has a problem, and I believe that that problem is that you don't have the funding to do half of the programs that you would like to initiate, and you don't have the funding because you don't have the budget. You don't have the budget because you don't really have the support and the commitment—

I underlined "commitment"—

> from the Congress and from our Government, from the administration. You don't have the commitment there because you really don't have the support and the commitment of the American people. I think that you need to do something about that. What I would recommend is that you send somebody up there in space who people can relate to a little bit more easily than they can, perhaps, to an astronaut. Someone who can come back and communicate, articulate not only the experience of space, but all of the spinoffs, all of the things that we have been blessed with that have come out of our space effort. Mr. Beggs, I would like to volunteer for that job.

This was, as I said, a little over 3½ years ago. I believe that this sort of started the ball rolling, if you will, and that brought about the flight last January that included Christa McAuliffe.

In fact, until President Reagan said, in his campaign a year ago last fall, that he wanted to send a teacher first, I believed that it was my flight. I will tell you today, I would have been proud to go. Even in retrospect, know what occurred, I would still have been proud to be on that shuttle. If given the opportunity, I would go tomorrow. I do hope some day to go into space for more reasons than I can possibly enumerate.

RISKS INVOLVED IN LIFE

One of the things that I looked at in thinking about this is the risk of it all. You know that it is a risk to get out of bed in the morning. We live in such a highly technological society that we have these automobiles that we drive around the country that can do speeds above 100 miles an hour. Hundreds of Americans are killed every year because we are not emotionally or intellectually and physically coordinated enough to handle these vehicles. Oftentimes, I look back on our history, and it is a shame that Christopher Columbus didn't have quality control back when he set sail. If he had, somebody might have said, you know, there are some weak links in this mast, I don't know whether it is going to stand up for your trip. What about our forefathers as they spread from the East and went across our great country to settle the West, there was no quality control on the Conestoga wagons that they had. Nobody really gave them a sure picture that they were going to be safe through the paths of the Indians out there.

Risk is a part of our life, and we have to accept it. I heard you make the comment, and talk about sitting on top, with a few other people, of how many thousands of pounds of fuel, and everybody else was 3½ miles away. It has got to tell you something. It is a risky business. But this kind of endeavor, anything that draws the human spirit is worth whatever the risk.

STRONGER ROLE FOR NASA ADVISORY COUNCIL

It occurs to me that the NASA Advisory Council could take a stronger role. As opposed to just articulating the visions and our hopes for the future out of NASA, perhaps here is a body of people who come from the civilian world who can have a little bit stronger role in overseeing things that are going on.

When they are listening to a discussion over here among the NASA Administration, and over here they are talking with some of the astronauts, and they find out that the astronauts don't know about this discussion, don't know about the O rings, or something, maybe they could give a little input here and there that could be very, very valuable in the future.

VALUE OF TEACHER ON BOARD

The last thing that I would like to say, sir. You know, when the *Challenger* exploded, for a couple of days, all over the world, everything stopped, and everybody in the world shared, not only our grief, but our loss. It was something that they experienced for themselves. I think that it primarily had to do with the fact that Christa was aboard that shuttle, because there was one of us. There was a human being, there was a teacher—not an astronaut, not a politician, not anything but one of us. Somehow, I think that touched the hearts of people all over the world.

For our country, I personally cannot think of a greater statement about America than the fact that that teacher was on board. I think that it says more about our country, about democracy, about our vision as Americans, our integrity, our dedication, not only to ourselves, but to the future of all human beings on planet Earth.

I think that it is an incredible thing. Nowhere else in history, and nowhere else today in the world is there a society which can provide that kind of opportunity.

We say that it is OK to send 18-year-olds off to war, to lose their legs or their arms, or their lives, but it is not OK to allow civilians to be part of our greatest glory. I disagree. I think that we deserve that opportunity, and I think that along with astronauts, along with our whole society, and along with all of humanity, space is our destiny. In space are the answers to many problems that we are dealing with all over the world today. In space is an opportunity for a new frontier, a catalyst, as Mr. Anderson said, to get young people serious about education again.

Our future is a broad and exciting, and demanding and challenging future that we face. So many young people that I run into around the country, who have this very narrow perspective, which is a source of great frustration to them, when you start talking to them about space, as you have mentioned, as Barbara has said, their eyes start to glow, and they see something there for them. I want very much to keep that dream alive, and I commit myself, anything that I can do to support you and your efforts, to support NASA, to keep our country moving in the direction that is onward and upward.

Thank you very much, sir.

[The statement follows:]

STATEMENT OF JOHN DENVER, INTERNATIONAL ENTERTAINER, SINGER, AND ACTOR

MR. CHAIRMAN; MEMBERS OF THE SUBCOMMITTEE; I AM VERY PLEASED TO BE HERE TODAY, ALONG WITH YOUR OTHER WITNESSES THIS MORNING, TO TALK ABOUT WHAT YOU HAVE DESCRIBED AS THE "INTRINSIC HUMAN VALUES" OF SPACE EXPLORATION. I BELIEVE, VERY STRONGLY, THAT YOUR USE OF THE WORD "INTRINSIC" IS APPROPRIATE WHEN WE TALK ABOUT ALL THE MANY THINGS THAT ARE INVOLVED IN MANKIND'S EFFORTS TO EXPLORE THE HEAVENS, AND BEYOND. THE WORD CALLS OUR ATTENTION TO THOSE ATTRIBUTES THAT ARE A PART OF SOMETHING BY ITS VERY NATURE.

BY ITS VERY NATURE, THE EXPLORATION OF SPACE IS AN EXPRESSION OF MANKIND--A STATEMENT ABOUT THE SORT OF HUMAN BEINGS WE ARE, AND HOW WE CARE ABOUT UNDERSTANDING OURSELVES, AND OUR PLACE IN THE UNIVERSE.

FROM THE BEGINNINGS OF HISTORY MANKIND HAS SOUGHT TO EXPLORE BEYOND THE PLACE HE FOUND HIMSELF LIVING; CIVILIZATION FANNED OUT, AND EVENTUALLY SPANNED THE GLOBE AS A RESULT OF PEOPLE SEARCHING BEYOND THEIR HORIZONS. IT WAS IN THEIR NATURE, AS CURIOUS BEINGS, HUNGRY FOR KNOWLEDGE AND EAGER TO OVERCOME THE CHALLENGES AND OBSTACLES TO THEIR SEARCH, WHETHER THEY WERE UNFORDABLE RIVERS, STORM-TOSSED SEAS, IMPASSABLE MOUNTAIN RANGES--OR IGNORANCE AND FEAR. NO OBSTACLE HAS YET PROVEN TOO GREAT FOR THE DETERMINED EFFORTS OF MANKIND TO EXPAND ITS HORIZONS.

THOUGH THE COST HAS BEEN HIGH, THROUGHOUT HISTORY, IN WEALTH AND RESOURCES, AND, YES, IN HUMAN LIVES, STILL MANKIND HAS PRESSED ON; THE SEARCH HAS CONTINUED; WE HAVE MET AND MASTERED THE CHALLENGES, AND FACED THOSE THAT ROSE UP TO TAKE THEIR PLACE. IT WILL ALWAYS BE SO; IT MUST ALWAYS BE SO, FOR THAT IS WHAT IS UNIQUE ABOUT OUR SPECIES, ABOVE ALL OTHERS. IT IS THAT INDOMITABLE WILL THAT ENOBLES US, AND PITS US AGAINST TESTS THAT FORCE US TO REACH BEYOND OURSELVES, AND TO REFUSE TO ACCEPT THE PREMISE THAT WE CANNOT ACHIEVE WHAT WE CAN CONCEIVE AND BELIEVE.

ALL OF US HERE TODAY, IN THIS ROOM, IN THIS CITY, THROUGHOUT THE WORLD, ARE THE BENEFICIARIES OF THE ADVANCES MADE BY EVERY SINGLE INDIVIDUAL SINCE THE DAWN OF CIVILIZATION. NONE OF THE TECHNOLOGY AND SCIENTIFIC EXCELLENCE THAT WE HAVE TODAY JUST APPEARED ONE DAY; WE DIDN'T JUST SUDDENLY START TO FLY AT KITTY HAWK, WITH NO PREPARATION, NO HISTORY OF EXPERIMENTATION, NO RECORD OF PAST ATTEMPTS. WILBUR AND ORVILLE WRIGHT WERE BLESSED WITH AN INSIGHT THAT HELPED THEM TAKE LITERALLY CENTURIES OF THOUGHT--AND DREAMS OF FLIGHT--AND FIND THAT CRUCIAL BREAK-THROUGH--THAT DELICATE BALANCE OF MASS AND VELOCITY AND AERODYNAMIC LIFT THAT LET THEM--FOR JUST A FEW MOMENTS, AT FIRST, "SLIP THE SURLY BONDS OF EARTH", AS JOHN GILLESPIE MCGHIE WROTE IN HIS FAMOUS POEM.

AND THE PIONEERS OF FLIGHT THAT FOLLOWED THE WRIGHT BROTHERS BUILT ON WHAT HAD BEEN LEARNED AT KITTY HAWK. EACH SUCCESSIVE BREAK-THROUGH WAS AN EXPANSION OF THE HORIZONS ESTABLISHED BY ITS PREDECESSOR, RIGHT UP UNTIL APRIL 12, 1981, WHEN COLUMBIA'S MAIDEN VOYAGE BROUGHT THE CONCEPT OF FLIGHT TO IT'S ULTIMATE EXPRESSION. AND ONE DAY, NEW CAPABILITIES, GROWING OUT OF OUR SHUTTLE EXPERIENCE, WILL LEAD TO FURTHER DEVELOPMENTS THAT WE CAN ONLY GUESS ABOUT TODAY--IF WE FOLLOW THE EXAMPLE OF THOSE THAT WENT BEFORE US; IF WE FACE AND ACCEPT THE CHALLENGES, AND COMMIT OURSELVES TO MEETING THEM, AND MOVING ON.

THE AMERICAN PEOPLE KNOW THAT; THEY KNOW OF THE INTRINSIC VALUE OF OUR SPACE PROGRAM. JUST LOOK AT THE LATEST GALLUP POLL, TAKEN TWO WEEKS AGO: WHEN ASKED IF AMERICA'S SPACE SHUTTLE FLIGHTS SHOULD CONTINUE, IN SPITE OF THE TRAGEDY THAT STRUCK DOWN CHALLENGER AND HER BRAVE AND SPECIAL CREW, EIGHTY PERCENT--EIGHTY PERCENT SAID YES! YES, LET'S FLY AGAIN! AND THAT WAS THEIR RESPONSE EVEN AFTER MILLIONS OF THEM WATCHED THAT TERRIBLE DAY, AND HAVE LISTENED, DAY AFTER DAY, AS THE REPORTS OF THE INVESTIGATION AND SPECULATION ABOUT WHAT HAPPENED AND WHY HAVE SEEMED TO RAISE DOUBTS ABOUT NASA AND OUR NATION'S ABILITY TO

FIND THE PROBLEM, FIX IT AND GET MOVING AGAIN. EVEN AFTER THAT, SEVENTY-NINE PERCENT SAID THEY HAD EITHER A GREAT DEAL OR A FAIR AMOUNT OF CONFIDENCE IN NASA'S ABILITY TO PREVENT SUCH AN ACCIDENT FROM HAPPENING AGAIN. ONLY NINETEEN PERCENT HAD EITHER NOT VERY MUCH CONFIDENCE OR NO CONFIDENCE AT ALL IN NASA'S ABILITY TO PREVENT A FUTURE ACCIDENT.

WHEN ASKED ABOUT WHETHER OR NOT CIVILIAN ASTRONAUTS, SUCH AS JOURNALISTS, POLITICIANS AND SCHOOLTEACHERS SHOULD FLY ON FUTURE SHUTTLE FLIGHTS, NEARLY SEVENTY PERCENT SAID YES, THEY SHOULD. I'M SURE IF THE QUESTION HAD INCLUDED ENTERTAINERS, WITH BLONDE HAIR WHO LIVE IN COLORADO, THE NUMBERS WOULD HAVE BEEN EVEN HIGHER.

BUT, IN ALL SERIOUSNESS, THAT SORT OF EXPRESSION OF THE PUBLIC IS BASED ON THE SUBJECT MATTER OF THIS HEARING THIS MORNING--THE INTRINSIC VALUE OF SPACE EXPLORATION. IF YOU ASKED EIGHTY PERCENT OF THE PEOPLE OF AMERICA WHAT WERE THEIR SPECIFIC REASONS FOR SAYING WE SHOULD KEEP FLYING, HOW MANY DO YOU THINK WOULD DESCRIBE A SPECIFIC PAYLOAD, OR SATELLITE, OR SPECIFIC MISSION AND SAY, THERE--THAT'S WHY? NOT VERY MANY. MORE LIKELY, THEY'LL SAY SOMETHING LIKE "BECAUSE IT'S IMPORTANT TO US", OR "IT'S SOMETHING WE HAVE TO DO".

THEY MAY NOT BE ABLE TO TELL YOU WHY, BUT THEY KNOW IT'S SO; THEY FEEL IT; THEY DREAM IT. LAST NIGHT, FOR THE FIRST TIME, I HAD THE CHANCE TO SEE THE FILM "THE DREAM IS ALIVE" AT THE AIR AND SPACE MUSEUM. IT WAS BREATHTAKING; IT WAS INSPIRING; IT WAS THRILLING; THE DREAM IS ALIVE, MR. CHAIRMAN. YOU KNOW THAT BETTER THAN MOST OF US, BECAUSE YOU'VE LIVED A PART OF IT.

BUT EVEN MORE IMPORTANT, FOR THOSE WHO MAY NEVER HAVE THE CHANCE TO ACTUALLY LIVE THAT DREAM, ARE THE BENEFITS THAT COME TO ALL MANKIND BECAUSE THAT DREAM IS ALIVE, AND BECAUSE WE ARE DOING THE THINGS THAT MAKE IT A REALITY.

YOU HAD TWO SESSIONS OF HEARINGS YESTERDAY THAT HELPED REMIND US OF THOSE BENEFITS. THE THINGS INDUSTRY, AND SCIENCE, AND MEDICINE HAVE GAINED FROM TWENTY-FIVE YEARS OF SPACE EXPLORATION

ARE ALMOST IMPOSSIBLE TO CATALOGUE. AS I BELIEVE YOU SAID IN YOUR OPENING STATEMENT, SENATOR GARN, THOSE HEARINGS ONLY REPRESENTED THE VERY TIP OF THE ICEBERG; IT WOULD BE IMPOSSIBLE IN TWO DAYS TO DESCRIBE EVERY APPLICATION OF TECHNOLOGY AND EXPERTISE AND INTELLIGENCE THAT HAS COME OUT OF THE SPACE PROGRAM, AND HOW THEY BENEFIT ALL OF MANKIND. I COMMEND YOU FOR ASKING US TO STOP AND THINK ABOUT IT, THOUGH, AND TO REMEMBER THAT PART OF THE INTRINSIC VALUE OF SPACE EXPLORATION IS THE WAY IT FOSTERS INNOVATION AND EXCELLENCE IN FIELDS THAT HAVE NO DIRECT RELATIONSHIP TO SPACE FLIGHT, AND YET DIRECTLY AND MATERIALLY AFFECT ALL OF OUR LIVES, AND GIVE US TOOLS THAT WE CAN USE TO MEET THE CHALLENGES OF DISEASE, HUNGER, AND MISUSE OF OUR PLANET'S NATURAL RESOURCES.

AS YOU IN THE CONGRESS LOOK AT BUDGETS, AS YOU HAVE TO, AND MAKE HARD CHOICES, AS YOU HAVE TO, HOW DO YOU WEIGH THE VALUE OF THOSE TOOLS THAT HAVE BEEN UNINTENTIONAL GIFTS TO MANKIND FROM THE SPACE PROGRAM? HOW DO YOU MEASURE THE VALUE OF LIVES SAVED, OR OF LIVES IMPROVED? HOW DO YOU PUT A VALUE ON RAPID DIAGNOSIS AND TREATMENT OF PREVIOUSLY FATAL DISEASES OR CONDITIONS WITH DEVICES THAT HAVE COME FROM SPACE TECHNOLOGY? I DON'T KNOW HOW YOU PLACE A VALUE ON HUMAN LIFE AND HUMAN PROGRESS. IT'S A VERY BROAD CONCEPT, AND DIFFICULT TO QUANTIFY. BUT ITS THERE, AND I BELIEVE THAT THE AMERICAN PEOPLE HAVE DEMONSTRATED THAT THEY UNDERSTAND THAT "INTRINSIC VALUE" OF THE SPACE PROGRAM BY VOICING THEIR SUPPORT FOR IT WITHOUT EVEN KNOWING THE RESULTS OF ANY KIND OF COST-BENEFIT ANALYSIS THAT COULD PUT A DOLLAR FIGURE ON THE VALUE OF THE BENEFITS FROM SPACE EXPLORATION.

I AM HERE TO ECHO THE VOICE OF THE PEOPLE ACROSS THIS LAND, AS THEY BEGIN TO STAND AND BE COUNTED IN FAVOR OF THE CONTINUATION OF THE GREATEST HUMAN ENDEAVOR MANKIND HAS EVER UNDERTAKEN. I AM INSPIRED BY THEIR ENTHUSIASM, AS I HEAR IT EXPRESSED EVERYWHERE I GO; AND I BELIEVE THAT THE CONGRESS AND THE ADMINISTRATION SHOULD LISTEN TO THAT OVERWHELMING VOTE OF CONFIDENCE.

THE SPACE PROGRAM WAS HURT DEEPLY BY THE LOSS OF CHALLENGER AND HER VALIANT CREW; MANY OF US FELT THAT LOSS EVEN MORE PERSONALLY, BECAUSE OF OUR CLOSE ASSOCIATION WITH NASA OVER THE YEARS, AS I KNOW YOU DID, SENATOR GARN. WE STILL GRIEVE IN OUR HEARTS FOR THE LOSS OF THE CREW, AND WE ARE CONCERNED ABOUT NASA'S RECOVERY AND RETURN TO SPACE FLIGHT. BUT, AS ONE ASTRONAUT SAID AT A MEMORIAL FOR THE CREW, IN HUNTSVILLE, "WE CAN TURN THIS TRAGEDY INTO A TRIUMPH". WE CAN LET IT REMIND US OF OUR HUMANITY AND OF OUR IMPERFECTIONS AND OUR VULNERABILITY; BUT WE CAN ALSO LET IT PROMPT US TO THE CREATION OF AN EVEN BETTER, EVEN MORE DEDICATED AND COMMITTED SPACE PROGRAM THAN WE'VE EVER SEEN. FOR WE CANNOT HONOR THE LIVES THAT WERE LOST ON CHALLENGER WITHOUT HONORING THE THINGS FOR WHICH THEY LIVED; WITHOUT PERFECTING AS FAR AS WE CAN THE PROGRAM FOR WHICH THEY DIED, AND WITHOUT EXPANDING THOSE HORIZONS BEYOND WHICH THE CHALLENGER SEVEN HAVE SOARED.

THANK YOU VERY MUCH.

WITNESSES COMMENDED

Senator GARN. Thank you very much, John. I don't know of any time, in the 12 years that I have been in the Senate, where I have had a panel of four witnesses where I agreed with everything each witness said. I do today, and I commend each of you for your testimony.

I would say to you, John, with your great desire to go, I understand that. I bugged Jim Beggs, if I can put it that way, for 4 years. The anticipation of the flight was so great, during the training period, that I often wondered, as we do many times in life, if the anticipation of something is greater than reality. I worried somewhat about that because I hated to go to bed every night hoping that the night would pass rapidly, so that I could get up in the morning and go play astronaut again. But the flight was at least 100 times more than my wildest imagination.

So if you think you want to go, I wanted to go the first time, knowing what it is like, now I would really like to go. I have one great regret, beyond the regret, of course, of the great tragedy happening at all, everybody wishes that it never had to happen, but thinking of Mike Smith, who was such a close friend, Christa and the others, if it had to happen on this flight, I am just sorry that it couldn't have been just 2 or 3 minutes later so that that crew could have seen the beauty of this planet from space. I really regret that they couldn't have seen it, and if it had to happen, that it couldn't have been a little bit longer because it is so magnificent to look back at this planet Earth. It is impossible to describe.

I hope that you, Barbara, and others have that opportunity to have that view. It will take your breath away. The first time that you float up to the flightdeck and look out, your heart will stop, and your lung will stop, and you will think, it is all right if I die right now, I have seen it all. It doesn't make any difference whether you come back or not.

We would like to go to a few minutes of questions for each of the Senators who would like to ask a few questions. Then at the end, when we finish the questions, because I would like to end the hearing on a note that Mr. Denver has composed. He has written one of the most beautiful songs that I have ever heard in tribute to the space program, and the *Challenger* seven astronauts.

I will let my colleagues go with questions for as long as they would like to, and then we would like for John to play his music, and then the committee will simply adjourn with simply no other words because I wouldn't want to spoil it after that.

John, you are one of those who, as I said, made the original proposals for civilians in space, and you are an experienced pilot in your own right.

JOHN DENVER'S POSITION ON SPACE UNALTERED

Has the *Challenger* tragedy altered your position on broadening participation in space at all?

Mr. DENVER. Not at all, sir. I still think that it was great. I congratulate our President for having the foresight to think of sending an educator up there first. I think that it is an incredible thing. I think that the opportunity of civilians to be in space is absolutely necessary. As I mentioned before, I would like to participate in any way that I can. I think that we must continue this. I am not at all disheartened by what occurred.

Senator GARN. You travel internationally a great deal, and speak with people all over this planet.

WORLD VIEW ON SPACE EFFORT

Have you had occasion to speak with people in foreign countries, and what are their feelings about space and our space program?

We have talked a lot about Americans today, what about the rest of the world?

Mr. DENVER. It is the same everywhere in the world. I have had many opportunities to talk about NASA and the shuttle program. Everywhere that I go, one of the nice things about my job, I have the opportunity to do an enormous number of interviews, either on television or with the press, and invariably, because of this long-standing role with NASA, there are questions about our space effort.

As opposed to a lot of other things, all of these questions are very positive kinds of questions. They are not questions that are looking to undercut me or my ideas, or anything about the space program. It comes, I think, from a real excitement that the people have about America's space effort.

One of the things that I have noticed, everywhere that I have gone in the world—Africa, the Soviet Union, China, and India—there is not a human being that I have met who doesn't remember exactly where they were and what they were doing when they first heard that man had landed on the Moon. It wasn't that an American had landed on the Moon, it was that man was there, one of us.

I think it is an incredible thing. As I mentioned in my testimony, I think that it is one of the reasons why the loss of the *Challenger* seven, and especially Christa McAuliffe, touched the heart of people all over this planet, because she, more than anyone, demonstrated that it was one of us up there. I continue to find that in all of my travels.

WORK OF NASA CHARACTERIZED

Senator GARN. You have also had a great deal of experience with NASA over the last 15 years and known a lot of the personnel, known a lot of the astronauts. How would you characterize the work of NASA and the work that they do?

Mr. DENVER. The first word that comes to my mind is "committed." They are truly a family. When you talk to people at NASA, from the people in the control room, the scientists, the people who are supporting the astronauts when they are working out on that floatation tank to experience weightlessness and to be able to operate in those cumbersome space suits, to the janitors that you meet, they all feel a part of each one of those flights. They all are committed to doing the best job that they possibly can because they know, no matter how small or large their role, they are a part of that great endeavor.

The commitment to doing the job is like nothing I have ever seen anywhere else in our world.

If I may, one of the things that has been very painful to me over the last couple of months, in reading the newspaper, in watching the press's observation of the hearings, or the President's Investigative Council and NASA's Council, there seems to be a lot of effort to put the blame on somebody, more than to just find out what went wrong.

When I think about that, I go back to that first conversation that I had with Mr. Beggs. I think that if anyone is to blame, Congress is to blame, with all due respect. Even more so, if you will allow me to say so, the American people are to blame. Even though we have had that support that has been expressed again, we haven't had the commitment. The people of this country haven't had the commitment to let our leadership know that this is something we want to have happen, and to work at its highest potential.

LEADERSHIP INDICTED

The leadership of our great country, as wonderful as you, gentlemen, are, you haven't had the foresight to see how incredible this is, not only for our country, but for everything that we aspired to in our relationship with other countries around the globe, to give the funding that is necessary to have this operation go on at full efficiency, full speed ahead, with everything that we can do.

When you start cutting back to fit in a budget, pretty soon you are going to start cutting back over here, one of these checks, this or that and the other, and it is going to result in the kind of accident that happened on the *Challenger.*

I hold myself responsible. If in some way, somewhere, I wasn't a strong enough voice, a loud enough voice to garner that support and that commitment from my constituency out there, the American public and around the world, and with the opportunities that I have to visit with you, gentlemen, you had better know that it is not going to happen again. My voice is going to get louder and stronger, I promise you that.

BARBARA MORGAN—IMPACT ON ROLE AS TEACHER

Senator GARN. Barbara, you haven't yet had the opportunity to fly, but how would you characterize the impact of your experience as a teacher in the space program so far, on your role as a teacher?

Ms. MORGAN. I am going to answer that from a personal standpoint. I have always believed that experience makes the best teacher, and although I haven't flown, I think I have had the very best experience. So I hope that it makes me become a better teacher.

I understand from what you have said that the experience I have had is nothing compared to what I will have when I do get to fly.

Also, another impact it has had on me is that my classroom has expanded, and that is really delightful for a teacher to have a classroom as large as the country and the world.

Also, I am really, really delighted to be part of a program that gives education what it deserves, and that is a very positive focus.

Senator GARN. How would you assess the impact, not only the personal impact that you have just described, but the impact on the teaching profession in the country?

Do you believe that just the fact that you and Christa participated has had a positive impact on the teaching profession?

Ms. MORGAN. Absolutely. I think it has, and I think that it will continue, especially as we continue to have a partnership with the space program. I can't tell you how many people came up to Christa and me during our training, over and over again, whether they were NASA people or people that we met when we were out on the road, saying that they have a sister or a brother who is a teacher that they are really proud of, or they know a friend of a friend who is a teacher, all who are doing wonderful things in their classrooms.

It was really delightful as a teacher—excuse me for saying this—not to have somebody come up to you and say, gosh, I know so-and-so who is a Senator; gosh, I know so-and-so who is a movie star, or a singer. I know somebody who is a teacher. I think that the prestige is going to help keep our good teachers in the classroom.

Christa and I had many discussions about this. In one of our discussions, she told me that out of 13 math teachers in her school, not the school district but in her school, 7 of them left this year. I think that this makes a really strong statement that goes along with what Jack said.

I also think that if students see that this will have an impact on students as well, because if students see teachers as having an important job, then they will see themselves, as students, as having an important job.

NEED FOR SCIENCE TEACHERS

What I am really hoping for, and what I hoped for when Christa went up, is this. A lot of people see astronauts, and they want to become astronauts. I was hoping that by sending Christa, some students would see Christa and want to become a teacher.

Senator GARN. I certainly agree with that last comment, which has not been emphasized. We talk about, and Jack talked a great deal about, the lack of science education. We need science teachers. The National Science Foundation is also under the jurisdiction of this subcommittee, and Pat and I struggle with that one, how do we encourage enough good, capable people to become math, science, chemistry teachers as well. That is a problem that we need to work on.

RELATIONSHIP BETWEEN YOUNG ASTRONAUT COUNCIL AND NASA

Jack, what is the relationship between the Young Astronaut Council and NASA? Is it a good working relationship that you have with them?

Mr. ANDERSON. It has turned into a very close working relationship. We were sort of imposed upon them by the White House at the beginning, but we have come to trust one another. Increasingly, we have come to understand one another. I think that I can understand a little bit about what is happening there now a little bit better than I could before.

I agree totally with what John Denver has said about the spirit of the people out there. These are committed people. These are the people who sent the first men to the Moon. These are the same people, and we ought not to forget that. These are people, about 40 percent of the top management, who are eligible to retire, most of them at full pension, and they are staying because they are committed. They are staying because they believe in what they are doing. Let's not drive them away.

I can tell you that there are always in this Federal, in every agency, those who play it safe. There are those who write these kinds of memos that we have seen lately in connection with the *Challenger*. The same memos were written before every launch, written by those who play it safe, by those who, if the launch is successful, can bask in the acclaim and, if it should fail, can pull out the memo and say, I told you so.

You will always have a small minority of people who are going to write memos and play it safe, but if the top managers are going to make their decisions based upon these few memos that appear before every launch, that appear before every major decision that is ever made, before every new project, before every new program, every new advance. If you are going to pay attention to these naysayers and doomsayers, we would have never gotten to the Moon. We would have never launched the first rocket.

I say that these memos have been taken out of context. I would like to have them publish the memos that were written about the successful flights to the Moon. Those also were supposed to have been doomed according to some of the very same people.

ACCIDENTS SHOULD NOT DETER SPACE EFFORT

Obviously, when an airliner crashes, we have to find out why. If it is something that can be remedied, it must be remedied. But I don't think that we should ground all airliners after each crash. I don't think that we should stop flying because there is a crash. I don't think that we should stop riding in automobiles because there are accidents. And because after millions of automobiles have been manufactured, we still turn out automobiles with defects. After millions of airplanes have been manufactured, we still turn out airplanes with defects.

You know, I believe that we are going to continue to be fallible. I think that we are going to continue to be imperfect. No matter what the Rogers Commission decides, I think that there are going to be future accidents in space. I hope that it doesn't keep us from going there.

I will tell you, while we have been contemplating our navels, while we have been anguishing and agonizing, the Soviets have sent a space station up there that is going to become the core of a major facility in outerspace that will include laboratories, manufacturing facilities, and living quarters.

During that same period, the European Space Agency has contacted all of the customers of NASA and said, "We will step up our program, come to us." The Japanese have increased their space effort.

I know that the front page tomorrow is not going to give us much attention. The front pages tomorrow are going to deal with the Contra issue, and the Gramm-Rudman issue, but let me tell you something, those will just be footnotes in future history books, if they are mentioned at all. Let me tell you what will be mentioned in future history books, what decisions we make now as to whether the United States goes into space, or whether it sits back and agonizes, and worries, and decides to take no risks. That is what is going to be reported in future history books.

Senator GARN. Let me assure you that we will find out exactly what happened. We will find out why. We will reengineer if it is the O rings and seals. We will find out if we need to change management procedures.

WE WILL FLY AGAIN

I was impressed with Dick Truly's press conference yesterday. We will start flying again. We will do it on a conservative basis. Just astronauts to begin with. There is no doubt in my mind that we will find out what happened, that we will find out why it happened, and we will be able to change procedures. We will learn from the experience, and the next shuttle that goes up will be safer than any of the ones that flew before.

We will fly again. It is a setback, and it will take us some time. I have talked with Senator Leahy, and he feels the same way. We have to look back at ourselves as determinate. We will hold hearings at the proper time, after all the investigations are completed, so that he and I, and the rest of the subcommittee, can gather information, and work with NASA to get them going again. We will.

Senator Leahy.

Senator LEAHY. Thank you.

Mr. Anderson, this committee, certainly in the Senate, more than anyone else, is going to have the responsibility of determining what kind of a space program we have. You don't turn the money on or off.

We determine what we put into that fiscal pipeline. We will determine what we are going to have in 5 years, 10 years, through the rest of this century. It is a responsibility that I think each of us on the committee, both Republicans and Democrats, take very, very seriously.

We can, in effect, slow almost to a halt the space program by stopping the money, or expand it by giving the funds. As I said, I cannot imagine the United States without a space program, we have to know best where to go with it.

ROGERS COMMISSION INVESTIGATION

I want to make sure that I fully understand your testimony. You are not suggesting, are you, that the Rogers Commission investigation was not a good idea, or are you?

Mr. ANDERSON. No; I think that it was a good idea. I think that we have to find out what happened. I think that we have to prevent it from happening again. I don't want Barbara to go up until we know why Christa had to die.

But I agree with John Denver. I was thrilled to hear him say that he would have gone up even on that *Challenger*, if he had been invited, and I think I would have. I am ready to go on the first one.

I think that the American people want to go. I understand that we have to find out the reasons why. As I said, we have to find out the reasons why airplanes crash and automobiles don't function, but we don't stop producing, we don't stop flying and we don't stop driving. I say, let's get back in space. Let's not sit around and wait. Let's not let our adversaries and competitors beat us in this most exciting of all human challenges.

TIES WITH YOUNG COSMONAUTS OF U.S.S.R.

Senator LEAHY. Also in your testimony, you spoke of the Young Astronaut Council, and I believe you mentioned similar ones in the Soviet Union. Have you been in contact with them, or have they been in contact with you?

Mr. ANDERSON. Yes; one of the first things that we did, after we were formed, was to establish ties with the Young Cosmonauts in the Soviet Union.

Senator LEAHY. Will you be engaging in any kind of joint activities with them?

Mr. ANDERSON. We have already had exchanges of letters. Before Geneva, I asked the President to include an exchange of Young Astronauts and Young Cosmonauts as one of the exchanges that he would advocate. He told me afterward that he had personally taken this up with Mr. Gorbachev, and Gorbachev had agreed to it in principle. At this moment, as we sit here, Ambassador Stephen Ryan-Smith, the President's personal representative, is in Moscow, and he has, as his first priority, to arrange an exchange of Young Astronauts and Young Cosmonauts.

Senator LEAHY. So you feel that you have the support of the administration behind you in that regard.

Mr. ANDERSON. Mike Deaver has told me that the Young Astronaut Program is the President's pet project.

Senator LEAHY. Good.

Mr. Denver, you have been over there, in the Soviet Union. It is always great traveling over there if I follow you, because everybody is still in a good mood. What do you gather from your own travels over there, do you find this kind of an interest in the Soviet Union?

Mr. DENVER. Absolutely. One of the things that I love about our efforts in space is that it so obviously includes all of humanity. One of the greatest times that the Soviets and Americans have worked together was the Apollo-Suyez launch.

When I travel to the Soviet Union, I meet people who are environmentalists, and we can talk about what is going on with the environment, with our planet, and politics, and the differences between our two cultures, and our two rich heritages, never come into questions. There is a common ground here that we are talking about.

The same is true about our space effort. I was privileged to meet Cosmonaut Leonov and get a tour around Star City when I was there a year ago last December. The stories that he told, and the things that I shared about my father teaching me how to fly. We had a grand time. I felt that the meeting started off as kind of a protocol thing that he had to do, and we ended up talking for several hours, and having a glass of Cognac, laughing, and talking about being grandparents. It all bridged this common interest and aspiration and the experience that he has had, and the desire that I had to share that experience.

ASSOCIATION OF SPACE EXPLORERS

I am aware of the Association of Space Explorers, which is made up of people who have flown in space from all countries. They had a meeting just this past fall in France. There is another opportunity for us to come together under this beautiful umbrella, and begin to find new and better ways to work together, to support one another, to achieve the dreams that we all have.

Senator LEAHY. You mentioned your father. I recall that he talked to me about flying with you, and how much he enjoyed that, and your discussions on landing tactics. I know how much he enjoyed that. I know that he would enjoy being on that trip with you.

Mr. DENVER. You betcha.

PRESENT ROLE OF MS. MORGAN

Senator LEAHY. Ms. Morgan, are you still in training, or has this been put on a hiatus?

Ms. MORGAN. I am still in training on a personal level, although my schedule is so busy that I haven't had a lot of time to keep up with it. I have a lot of reading to do. I just started back last week. I have had a very, very busy schedule. I went to New Orleans, and I have been here for 2 days. I am going to San Francisco to speak to the National Science Teachers Association at their annual meeting. From there, I go back for a couple of days, and then it is off again to San Antonio, literally going all over the country, giving talks to teacher groups, civic organizations, and school children about the program and my personal experiences.

Senator LEAHY. Right now, is it necessary to do much more of the speaking and the public relations aspects? Do they have you on a nonphysical training program?

Ms. Morgan. I would have liked to have stayed there, to continue my training. Senator Garn indicated what great folks they are, how committed they are to the program, and to their own work, to include Christa and me, and really make us feel like a part of the family. It was really quite an experience. I do plan on going back there. Hopefully, when I have a little bit more of a break in my schedule, I would like to go back there. I am planning on going back to the classroom next year. And during my Christmas and spring breaks, they have invited me to come back and have some training, to try to keep up my skills.

Senator LEAHY. But right now, your schedule is primarily a speaking schedule. You plan on going back to school in the fall. Will you take your training during the Christmas break and in the spring.

Ms. MORGAN. Yes; until NASA has a schedule.

Senator LEAHY. Then you will concentrate on your training program at that point.

Ms. MORGAN. Like Christa and I did from September to January.

Senator GARN. Explain that there are two phases of training. There is individual training, which can be done at any time. Once you are assigned to a crew, then you have to keep up with certain things, and you have integration training, which involves not only the crew members, but it involves the centers, the whole network.

In my case, I was able to run back and forth on the individual training, but once I was assigned to a crew, then the Senate was gone and, similarly, her teaching will be gone. She will be part of a crew training, very intensive training.

Senator LEAHY. I intend to go down and perhaps spend some time this spring, spend a couple of days both in Texas and in Florida, to obtain a handsoff overview of what the training is like. I would like to go to Cape Canaveral for a couple of days to see more than what I see here, and more than what I hear.

Ms. MORGAN. May I make a comment. I would like to say that you are going to enjoy it a lot. My training was the height of my experience so far. The training goes a little bit beyond, or quite a bit beyond what I would actually be trained to do on the shuttle itself. I want to learn as much as I can about NASA so that I can share all with my students, and by my students, I mean the students all across the country, and the world.

Senator LEAHY. You have a lot of students on Capitol Hill. A lot of us looked forward to hear from Ms. McAuliffe when she came back. I think that all of us on the various committees that handle the space program are looking forward to having the testimony coming from somebody who has not only the background, but whose vocation really is teaching.

Ms. MORGAN. She would have done an excellent job.

Senator GARN. You can go down for a couple of days, and we, at least, ought to arrange a vomit comment ride for him. [Laughter.]

Senator LEAHY. No; I can't fit everything in there.

Senator LAUTENBERG. He has to get in a suit first.

Senator LEAHY. As vice chairman of the Intelligence Committee, I have to keep my wits about at all times, otherwise I would do it.

Ms. MORGAN. I think that he would enjoy that, and I think that he should try the WCS training as well.

Senator LEAHY. I think I will find out what WCS stands for before I try it.

Senator GARN. We won't explain that in detail. That is the waste collection system. I would only say, I don't know if you have experienced this, but——

Senator LEAHY. I don't want to experience it on television, if that is what you are talking about.

Senator GARN. Adults do not ask this question, but every grade school I have been in, there is always a little kid who says, "How do you go to the bathroom in space?" There is no way that you are going to describe it, only to your most intimate friends, even then you are not. [Laughter.]

My standard answer, which you might use, kind of solves it, and they get an understanding, you just say that gravity is very helpful to certain bodily functions, and that takes care of it.

Senator Lautenberg.

Senator LAUTENBERG. I guess, with that introduction.

Senator LEAHY. Be very careful on the followup questions at this point. [Laughter.]

Senator LAUTENBERG. My answer to, "How do you go to the bathroom in space?" would be, very carefully. [Laughter.]

Senator GARN. That, too.

Senator LAUTENBERG. I am pleased to have such a distinguished panel appear before us. You make a great contribution, just by your appearance here today, to the continuation of our space program. You raise it to a level of consciousness, I think, that is critical if we are to continue.

I don't want Mr. Eskin to feel left out with that group of celebrities that you are sitting with. You, too, make a major contribution even though you are not quite as famous.

Senator LEAHY. You should hear him sing, though. [Laughter.]

Senator LAUTENBERG. I thought that John Denver and I were going to do a duet here.

Senator GARN. We wouldn't want to destroy his career.

Senator LEAHY. Mr. Chairman, I have to leave at that point.

Senator LAUTENBERG. You will notice the abuse. I am a freshman, despite the white hair, and one pays a price for that position.

Senator GARN. Some of us wouldn't care what color we had. [Laughter.]

Senator LEAHY. If it would come back, I would take it green, I don't care.

Senator LAUTENBERG. I want you to remember that before Senator Garn went into space, he had a full head of black hair. [Laughter.]

In any event, your contribution is a very important one.

I think that we have to share some, perhaps, if not alternate views, some questions about some of the things that we are reviewing.

A hearing has its purpose, to learn, not only for us, the Senators who sit on these panels, but the public at large that hears the information and sees it recorded.

DANGER INHERENT IN EXCESSIVE CRITICISM

I take this mission very seriously, as you would expect, and as we review those wonderful parts of space exploration, we have to call into question how we deal with it. I am concerned, as we go through the process of criticism, of examination, that we don't damage, not only the spirit of those who would fly—I use it in the best sense of the word—those who would explore, those who would challenge, but those also who have a responsibility to see that what we do, we do with the greatest care and efficiency that we can possibly muster.

Mr. Anderson, you talked about the memo writers. I know you don't intend to degrade the efforts of those who remind us at times about what our responsibility is.

We have had several debates here. Let me make the record clear here, first of all, and that is that I agree with all of the positive things that you said about opportunities in space, each one of you. Cooperation between nations, science, medicine, communication. I came out of the computer business before I arrived here, and I know what a significant difference space communications made in our ability to function better in the industrial and economic worlds, and to learn.

I think that we would be remiss, I speak for myself, if I didn't continue to examine the way we spend our money. The American people are a good people, and they are willing to spend money for things that they get value for. That is kind of a characteristic of our people. The one thing that I think we dare not do is dismiss criticism, the challenge, of those who raise the question about whether we have done as much as we can in terms of making certain that to the best of our ability, and man is fallible, but to the best of our ability, we have done the best in technique, technology, and process, and so forth.

We have spent $120 billion in the last 20 years on space exploration, some of it military, more now military than peaceful. I just want this record to reflect the fact that there are those who are conscientious about their responsibilities. Maybe they are not flying, but they are part of the program, they range somewhere between the janitor and the astronaut, who feel just as committed to the space program as any one of us today here does.

But their job is to say: Have we done this right? The memo is the proper thing in many cases. If all it does is say, no, then it doesn't provide any value. On the other hand, if it makes us just a little bit better, if it extends the quality of our research, or the depth of the probe, then I think that it serves a function.

Mr. Denver, John, for some reason or other, you are a household name, and it is very hard to call you Mr. Denver. I know that it is true for you, too, Jack. I will call you John, if I might.

Mr. DENVER. Please.

CONCERN FOR ENVIRONMENT

Senator LAUTENBERG. I share your views on another subject, John, the environment. You are concerned about the environment, the preservation of our forests and our lakes and our streams, are you not?

Mr. DENVER. Absolutely.

Senator LAUTENBERG. You sing about it. You talk about it. You are concerned about the environment in which we live, and I share that concern. I sit on the Environment Committee. My colleagues here also share the concern about the environment, about a cleaner environment. We had discussions about that yesterday.

But you do know that in order to have a cleaner environment, we have to pay for it. We would like to continue as much effort behind the space program. You will ride in space one day, and you will come back here and tell us about the thrill of that experience. We all look forward to hearing about it. We will be riding along with you emotionally.

We are a nation strapped for resources at this point, and maybe we have to make a choice sometimes between the projects in space, and whether or not we have a cleaner environment. This subcommittee reports an appropriation bill that includes spending for space and spending for the environment. We have to make choices. Those are not pleasant choices to make. I don't want to throw cold water on the wonderful feeling that we are all sharing today, but I just want to make certain that we understand.

Mr. Anderson, you talked about the other nations that are so far ahead of the United States in educating their young, but they don't pay the price for defending the free world. Japan doesn't step up and take her share of the burden for defending the free world. Instead she has a lot of resources to use, whether it is for education, or competition, sometimes unfairly, in the business world.

So the problem is not a simple one, it is a very complicated one. We have to continue to apply the resources to space, that is mankind's frontier. Heaven knows, I use the expression carefully, what lies ahead for us there in the years ahead, and we will see things that we never dreamed existed. So we have to continue.

I would like the understanding of each one of you, and those who read this record and who see this hearing, to know that we are working with spare resources, that we are trying very hard to enlist the support of the American people for lots of programs that are essential. Education is critical. Without an educated youth, where would we be in 20 or 40 years. We won't be able to maintain the space programs, and we are not going to be able to take the leadership, not only in science, but in business, government, universities, and things of that nature.

I would like to have your cooperation on those programs that ultimately lead to a better world for all of us.

PEACEFUL VERSUS MILITARY USE OF SPACE

John, I know that you share some concerns, do you not, about peaceful use of space versus military use of space? Did that subject come up at all in your trips abroad?

Mr. Denver. Absolutely, Senator. If I may add to that, again, as you suggest, for the record, and with great consideration for everything that you are saying.

You mentioned the figure of $120 billion over the last 20 years that NASA has spent.

Senator Lautenberg. It is not just NASA, it is all space exploration.

Mr. Denver. We spend twice that amount every year in the military. I had a friend, Buckminster Fuller, who talked about investing in livingry as opposed to weaponry. I remember Dwight Eisenhower, when he left office, when he first coined the phrase, "the military industrial complex." He said in his speech that every time we make another missile, we are taking food out of the mouths of hungry children. Every time we make another weapon system, we are taking tool of possibility out of the hands of the poor.

I look at the advances that Japan and Germany have made since the end of the second world war, two countries that were decimated and are now among the very strongest economically, creatively, and every other aspects. They are talking now of Japan being the new banker of the world. How did that happen?

I propose to you that it came out as a result primarily of one thing, by treaty, the Japanese and the Germans were not allowed to develop a defensive mechanism, a defensive system, either technologically or with human involvement. So they were forced to invest their resources, their creativity, their talents, their commitment in other areas, areas like livingry.

It is out of this commitment, out of this structuring, if you will, that they have come to be the major forces that they are in the world today. I propose to you, as we look at these balances, and as we want to do something about hunger on the planet, as we want to take care of the environment, and make the best use of our resources, that we are coming to a point in our history, not only is the United States, but as human beings on the planet, where the appropriate investment is no longer in weaponry.

What are we making weapons for? Why keep on feeding this war machine? There are better things that we can do with that money, for the environment, for humanity, and certainly on our efforts in space.

Senator LAUTENBERG. You talk about cooperation in the space program as a way to bring nations together. Your belief in that is supported by your activities.

Mr. Eskin, what do you think, does something like the SDI program in any way upset the ability for nations to cooperate in our space program?

Mr. ESKIN. It has not affected our ability to cooperate with our friends and allies.

Senator LAUTENBERG. You have had no negative response, no concerns about that kind of a development.

Mr. ESKIN. Not with the active international cooperation in space. It is a different case for the Soviet Union. The SDI program has been cited by the Soviet Union as an obstacle to cooperation with the United States.

DOD SPACE SPENDING DOUBLE NASA'S

Senator LAUTENBERG. Does it disturb you at all, John, that in 1965, the ratio was about 2 or 3 to 1 spending by NASA versus spending by DOD for space. The ratio is exactly reversed today. We are now one part NASA, two parts Defense, in terms of space exploration.

John Denver, does it disturb you that DOD is spending twice as much today for space exploration as is NASA?

Mr. DENVER. Yes, sir, dramatically.

Senator LAUTENBERG. Mr. Eskin, how does that strike you in terms of international cooperation?

Mr. ESKIN. Obviously, from our point of view, the question of investment in defense and the space program is not an either, or proposition. We have national security interests that have to be considered. I don't think that we would look at it as we either have to have a civil space program or look at our national security purposes.

Senator LAUTENBERG. From your focus of getting the countries of the world to cooperate, especially among our friends, I guess, don't we get more cooperation, a better understanding among our friends and allies, if we focus more on the peaceful side of things than we do on the military side?

Mr. ESKIN. In all candor, I can't actually agree with that proposition.

Senator LAUTENBERG. I won't press you on that.

Mr. Anderson, do you have any view of that?

Mr. ANDERSON. I think that we have got to defend ourselves. The people who control the high ground have always had an advantage. Those who control the mountains usually have an advantage over those in the valley. In World War II, those who controlled the air had an advantage over those on the ground.

I have a nervous feeling that those who control space militarily will be able to control the Earth. As long as the Soviets are building space weapons, I would have to reluctantly and sadly agree that we must do the same.

On the other hand, one of the things that our program seeks to do is to bring together the future space explorers, the children of Russia and the children of the United States, and see if at that level we cannot look into space and see the peaceful prospects that are out there.

Senator LAUTENBERG. But we don't want a young population that looks like theirs, do we? We want a young population that has the ability—John said it so eloquently. In this society of ours, in this structure, you have the ability to ask the questions; you have the ability to make statements; you have the ability to function and go where you want to go, and do what you want to do. In the Soviet Union, you can't do that because of their enormous focus, it takes so much of the resource, put into the military, and that is how they keep that fragile society together, by constantly drumming up the enemy, and spending all that money that they have. So much goes into defense that there is nothing left for life. There is nothing left to educate the broad spectrum of young children. You either march in step, or you are out of it. We don't want that.

We don't want to emulate the Russian society to where so much of our resource goes into the military. We think that there is more to life than that. John, do you agree?

COST OF WEAPONRY RACE

Mr. DENVER. Yes, sir; that scenario that you describe, that is very accurate, in my opinion, starts to sound like what is happening in our country. What is it costing us to continue on this path of competition in weaponry?

What is it costing? Ask any American farmer today what it is costing us. Ask Barbara what it is costing teachers. A couple of years ago in a Denver high school, a young girl was knifed to death by one of her classmates, a sophomore in high school. There are a lot of things that are not available in a lot of our high schools in our country today that were something that I took for granted when I was in school—counseling, dramatic programs, girls athletics. Why aren't those programs in our schools today? Because they don't have the funding. Why don't they have the funding? Guess.

We are creating the same scenario that you describe already the fact of the matter in the Soviet Union. I think that this is something that we need to be very, very cautious of.

I think that here in space, here is an opportunity when we can take, let's say, let's make an agreement with the Soviet Union to take 1 percent of what we are both spending on defense systems and national security, and let's put that toward the Young Astronauts Program, the Young Cosmonauts Program, or let's put it toward building a space station together in space.

ELIMINATING HUNGER

Let's take 1 percent of our defense budget, both of our countries, and let's work together to end hunger. One of the reasons that I am so involved in the hunger issue, and have been for over 15 years, is because I know that we can solve hunger, as Senator Leahy and I discovered when we served on President Carter's Commission on World and Domestic Hunger.

We have the wherewithal to eliminate hunger, but we are not going to do it by ourselves. It is going to take all of us. So here is an opportunity to work together to end hunger.

Conquering space, stretching man's horizons is not something that the United States is going to do by itself. It is going to take all of us. Here is an opportunity to work together, let's do it. If peace is our vision, let us begin. Let us look for every opportunity to demonstrate that it is our vision, and that it is our commitment.

Senator LAUTENBERG. I couldn't have said it better.

Mr. Chairman, I will pause right now just to say that, again, the programs you present, and the attitude that you present here today are very positive.

Jack Anderson, that Young Astronaut Program has got to be one of the most exciting things that young people can look at and aspire to.

Barbara, bless you for your view on education, for the things that you said about what happens. It sounds a little bit cornballish to talk about the elevation of the teacher by putting her up in space. But too long, we haven't respected the role that the teachers play in the shaping of young lives. It is demonstrated in inadequate salaries, in inadequate facilities. Education is where the planting is done. That is where the nourishment is done. That is where you grow the crop that will feed all of us one day. That is the development of the human mind.

Thank you, each one of you, for being with us today. I hope that you understand that this exchange of mine was one to continue the program, and to make sure that we do it on the right path.

Thank you very much, Mr. Chairman.

MILITARY SPENDING DEFENDED

Senator GARN. Before we conclude—I am sorry that we even got to talking about the military in this hearing, but I can't let it leave with the impression that military is robbing the space program with this 2-to-1 ratio.

John, you responded that you didn't like that. I just think that it is necessary to say what those military expenditures are for. They are for communication satellites so that we can talk to our airplanes and our ships. They are for navigation systems that you use as a pilot, for NAVSTAR, and things that all get lumped into the military, but there is not a single military item in space that has anything to do with attacking anyone.

NEED FOR VERIFICATION

One of the most important things. Senator Leahy and I have served on the Senate Intelligence Committee for a number of years. I am no longer on it. In the SALT II debates, one of the biggest arguments was the matter of, How do we verify. When we lost Iran, we lost some of that capability. I think everybody would agree, whatever we ultimately agree with the Soviet Union in a treaty, it must be verifiable. We lost the ability to monitor certain aspects of SALT II. Our answer to that was what is known as national technical means; that is satellites, high-flying satellites to check and verify.

You and I would both like to see an arms control treaty. Without those satellites out there, we can't have one. I just wanted to make it clear that that 2-to-1 ratio, that military expenditure being spent is navigation, communications, spy satellites. They don't harm anyone. As a matter of fact, I think they help the peace process. That is where I would like to keep space, for those types of purposes.

Plus, we also worked out an agreement in this subcommittee to help NASA be able to fly the teachers, and the communication satellites, and so on, by eight launches per year being flown with these satellites for the militry, which helps compensate NASA. Part of it goes into the building of the Vandenberg site, built by the military as a contribution to NASA, so that the polar orbits could be flown.

I just didn't feel that I could leave that hanging. There needed to be an explanation of what those military expenditures are—peaceful purposes all the way across, and a great help to NASA. If you cut back dramatically on the so-called military portion of space, you wouldn't keep the shuttle in the air. It was necessary to have a commitment from

DOD to buy from NASA eight flights per year, for those communication satellites and navigation satellites.

I just wanted to put that in perspective, and not leave it hanging. I would agree with the Senator from New Jersey, if we were putting offensive weapons out there, I would answer the same way you did. I hope you will forgive me, but I did want to make sure that everybody knew what those expenditures were for.

WITNESSES EXTOLLED

We do thank all of you for coming. Your testimony has been incredibly valuable to the subcommittee. You have put a positive light on what is going on. Someone said, "You are only having witnesses who are positive"; that is deliberate. I think over the last 2 months, the other side has adequately had their day in court, day after day after day, night after night after night. I didn't feel that it was necessary to have that. We have all herd that, and I think that it is time that we start the process back with the other side of the coin being heard, the positive aspects of our space flights.

We thank you for coming.

John, we will simply close with your beautiful presentation. I hope that I have a big handkerchief with me. There will be no more words spoken and the hearing will be adjourned at the conclusion of your presentation.

Mr. DENVER. Senator, I thank you very much on behalf of all of us here for calling these hearings for just the reasons that you articulate. I thank you especially for clarifying something I was a little bit dark and murky about with regard to the military in space. I feel a little bit differently now.

I appreciate the questioning, and I appreciate so much the opportunity to speak my mind here with all of you.

"FLYING FOR ME"

This song—I started writing on January 28 and I finished it a couple of weeks ago. So we recorded this just 4 days ago, and I am very honored to have the opportunity to share it with you all. It is called, "Flying for Me."

[The song, "Flying for Me," was played. The lyrics follow:]

"FLYING FOR ME"

Well I guess that you probably know by now
I was one who wanted to fly
I wanted to ride on that arrow of fire right up into Heaven
And I wanted to go for every man
Every child, every mother of children
Wanted to carry the dreams of all people right up to the stars

And I prayed that I'd find an answer there
Maybe I would find a song
Giving a voice to all of the hearts that cannot be heard
And for all of the ones who live in fear

All of those who stand apart
My being there would bring us all a little step closer together

They were flying for me
They were flying for everyone
They were trying to see
A brighter day for each and everyone
They gave us their light
They gave us their spirit and all they could be
They were flying for me
They were flying for me

And I wanted to wish on the Milky Way
And dance upon a falling star
I wanted to free myself
And give myself
And join myself to it all

Given the chance to dream it can be done
The promise of tomorrow is real
Children of Spaceship Earth
The future belongs to us all

She was flying for me
She was flying for everyone
She was trying to see
A brighter day for each and everyone
She gave us her light
She gave us her spirit and all she could be
She was flying for me

They were flying for me
They were flying for everyone
They were trying to see
A brighter day for each and everyone
They gave us their light
They gave us their spirit and all they could be
They were flying for me
They were flying for me

SUBCOMMITTEE RECESS

[Whereupon, at 11:51 a.m., Wednesday, March 26, the subcommittee was recessed to reconvene at 2 p.m. the same day.]

NASA SPACE PROGRAM

WEDNESDAY, MARCH 26, 1986

U.S. SENATE,
SUBCOMMITTEE OF THE COMMITTEE ON APPROPRIATIONS,
Washington, DC.

The subcommittees met at 2 p.m., in room SD-192, Dirksen Senate Office Building, Hon. Jake Garn (chairman of the Subcommittee on HUD-Independent Agencies) presiding.

Present: Senators Garn, Stevens, Domenici, D'Amato, Stennis, Hollings, and Lautenberg.

DEPARTMENT OF DEFENSE

DEPARTMENT OF THE AIR FORCE

ACCESS TO SPACE

STATEMENT OF HON. EDWARD C. ALDRIDGE, JR., UNDER SECRETARY OF THE AIR FORCE

JOINT HEARING

Senator GARN. The subcommittee will come to order.

This afternoon the HUD-Independent Agencies Subcommittee and the Defense Subcommittee are holding a joint hearing. The hearing follows three hearings that the subcommittee held on this issue last year.

Last year, the focus of our hearings was on the DOD proposal for a $2 billion complementary expendable launch vehicle, commonly known as CELV's, and the program was to provide a backup to the shuttle system. Unfortunately, and tragically, our worst fears and concerns over the potential requirement for this backup capability have been realized.

We must, and we will find out what went wrong with the last *Challenger* launch. We are going to fix the problem and we are going to continue to fly in space.

I might add that the hearings this morning were especially positive, and provided a great deal of good testimony about the spinoffs from NASA, the things that we gain every day here on Earth from our space endeavors and from space technology. The hearings have gone even better than I had anticipated they would.

In the last day-and-a-half, the HUD Subcommittee has reviewed the incredible diversity and the value of our Nation's space program. This

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hearing, in part, reaffirms our Nation's profound and growing dependence on our space program, not only in science and technology leadership, but indeed in our security and our survival.

UNDERSTANDING OF "CHALLENGER" FAILURE CRUCIAL TO CONGRESSIONAL UNDERSTANDING

Senator Stevens and I agree that it is critical that the Congress have a full understanding of the deep and complex repercussions of the *Challenger* accident on both the civilian and national security aspects for our space program. We face many difficult choices in the weeks and months ahead, not only in addressing very severe budget constraints, but also in the very real and substantial policy implications of the decisions that we will make.

Finally, I would like to repeat the concerns that we noted in our memorandum about this hearing. First we hope to keep this session open so questions on classified matters will have to be reserved for another meeting. Second, this hearing is to assess our existing and prospective launch capabilities, so we are asking for the cooperation of our membership to defer issues relating to *Challenger* accident investigation.

We would hope to have hearings after the other investigations are completed. I do not feel personally that we should be involved in that phase of it at this time. So these hearings are prospective, to look at where we are going from here. I assure you, we will fully review the findings of the President's Commission and NASA's own investigation at the proper time.

Senator Stevens.

OPENING REMARKS OF SENATOR STEVENS

Senator STEVENS. Thank you very much. I am pleased to join together in this joint hearing. I am happy to see you gentlemen here to give us information that we need. There is no question, as Senator Garn says, that maintaining access to space is a national priority at the very highest level for national defense. That is my area, defense. Senator Garn has his own special expertise as the chairman of the HUD-Independent Agencies Subcommittee. We want to look into the whole question of where we are and where we are going.

There are many critical national security requirements that require access to space, that I hope will be brought out here today—communications, reconnaissance, ballistic missile early warning, navigation, positioning, meteorological and oceanographic data collection. We are really just beginning to understand what it means to have had the *Challenger* accident, and there are difficult problems for us all.

I want to join with Senator Garn and indicate that we are not going to get into any kind of review of the tragic *Challenger* accident; that is not our function, but we would like to know what the alternatives are for the defense aspects of the NASA program now that we do not have *Challenger*. I look forward to this hearing settling some of the problems between us so that we don't have a similar problem develop in terms of marking up our defense appropriations bill as we had last year. We did have a time where we had to stand aside and have an independent review of the NASA impact, and I would like to have these things on the record and settled before we get to markup this year.

I am very pleased to be with you, Senator.

Senator GARN. Thank you, and I certainly agree that we need to make our decision early on what direction we are going to go.

Secretary Aldridge, we are happy to have you here with us today, if you would like to proceed.

SUMMARY STATEMENT OF MR. ALDRIDGE

Mr. ALDRIDGE. Yes, Mr. Chairman.

I have submitted a formal statement for the record, and what I would like to do today is to just briefly summarize that statement, and then I will be glad to respond to any questions.

First of all, I would like to make five points.

First, we in DOD strongly support the policy that we should return to a space launch posture that is stronger, more diversified, and more robust than existed before the *Challenger* accident. As you know, I have been advocating such a launch posture for the last 3 years.

Second, the impact of the *Challenger* loss and the fleet downtime that will result will have a serious impact on DOD's space missions. A downtime of only 1 year will result in 10 DOD payloads waiting on a launch pad.

Third, there is nothing that we can do within the next 2 years to mitigate the effects of the downtime and the reduced flight rate. We must simply live with what launch capacity now exists. Without congressional approval of the expendable launch vehicle program last year, we would be 4 years away from recovery.

Fourth, to mitigate the longer term impacts, we must act now with the fiscal year 1986 budget, to expand our launch capacity in the next 2 to 3 years.

Finally, we must expand our launch capacity in a balanced way, procuring a replacement orbiter to more competently meet our national manned space flight requirements, and expanding the use of expendable launch vehicles [ELV] to meet DOD unmanned space flight requirements. The expanded ELV production should provide a strong base for the United States to develop a commercial ELV industry to further augment our space launch posture.

We are working on a joint recovery plan with NASA, and the other Federal agencies, that can be submitted to Congress in the very near future.

Mr. Chairman, these are all the summary comments that I would like to make at this time.

Senator GARN. Thank you very much.

[The statement follows:]

STATEMENT OF HON. EDWARD C. ALDRIDGE, JR., UNDER SECRETARY OF THE AIR FORCE

MR. CHAIRMEN AND MEMBERS OF THE JOINT COMMITTEES:

I APPRECIATE THE OPPORTUNITY TO APPEAR BEFORE YOU, ALTHOUGH I WISH IT WERE UNDER HAPPIER CIRCUMSTANCES. IN FACT, I WISH THAT I WERE HERE TRYING TO DEFEND THE NEED FOR ELVs TO COMPLEMENT THE EXISTING FOUR ORBITER FLEET -- AS I HAVE DONE FOR THE LAST TWO YEARS.

UNFORTUNATELY, RECENT EVENTS HAVE MADE THE NEED FOR ELVs AND THE NEED FOR A MIXED FLEET OF LAUNCH VEHICLES MANDATORY. THIS REQUIREMENT NO LONGER IS ONE OF AN "INSURANCE POLICY" AS IT ONCE WAS CLAIMED BY MANY OF ITS CRITICS. THE ISSUE OF WHETHER OR NOT WE NEED ELVs NOW NO LONGER EXISTS. THE ISSUE IS WHAT IS THE MOST APPROPRIATE NATIONAL SPACE LAUNCH POSTURE.

THE CHALLENGER ACCIDENT HIGHLIGHTED THE VULNERABILITY OF OUR RELIANCE ON A SINGLE SPACE TRANSPORTATION SYSTEM FOR ALL U.S. SPACE ACCESS REGARDLESS OF REDUNDANCY AND HIGH RELIABILITY. HOWEVER, THIS ACCIDENT SHOULD IN NO WAY QUESTION THE VALUE OR SUCCESS OF THE STS PROGRAM AND THE UNIQUE CAPABILITY THAT IT OFFERS THE NATION. THE OBJECTIVE OF OUR RECOVERY STRATEGY SHOULD BE TO LEARN FROM THIS TRAGIC LESSON AND REBUILD A STRONGER AND MORE BALANCED NATIONAL CAPABILITY THAT IS LARGELY INDEPENDENT OF FAILURES IN A GIVEN SYSTEM. WE MUST STRUCTURE OUR SPACE PROGRAM SO THAT BOTH THE NATIONAL LAUNCH CAPABILITY AND MANNED SPACEFLIGHT PROGRAM ARE STRENGTHENED AND MORE FOCUSSED AS A RESULT OF THIS EXPERIENCE.

AS A RESULT OF THE CHALLENGER LOSS, THE NATION IS NOW FACED WITH:

- AN ORBITER FLEET DOWN UNTIL AN APPROPRIATE FIX TO THE PROBLEM CAN BE IMPLEMENTED — ESTIMATES OF THE DOWN TIME RUN BETWEEN 1 AND 2 YEARS;
- A THREE ORBITER FLEET TO FLY AN ANTICIPATED 24 FLIGHTS PER YEAR. ONLY TWO OF THOSE ORBITERS, DISCOVERY AND ATLANTIS, ARE CAPABLE OF FLYING THE HEAVIER DOD MISSIONS;
- A GROWING BACKLOG OF SHUTTLE MISSIONS - DOD AS WELL AS CIVILIAN - RESULTING FROM THE DOWN TIME AND FROM ONLY HAVING A THREE ORBITER FLEET;

AS A RESULT OF CONGRESSIONAL APPROVAL OF CELVs AND TITAN II SPACE LAUNCH VEHICLES, OUR ELV INDUSTRY IS NOW CAPABLE OF PROVIDING ADDITIONAL ELV LAUNCH CAPABILITY IN A LITTLE OVER 2 YEARS. WE ALSO HAVE THE CAPABILITY TO BUILD A REPLACEMENT ORBITER IN 3 TO 4 YEARS.

NEAR-TERM IMPACTS

THE SERIOUSNESS OF THE IMPACT TO DOD OF THIS TRAGEDY TO A GREAT EXTENT DEPENDS ON THE DOWN TIME OF THE ORBITER FLEET AND WHAT ACTIONS WE TAKE NOW TO RECOVER OUR SPACE LAUNCH CAPABILITY.

IF THE STS IS DOWN A YEAR OR MORE, THERE ARE SERIOUS NEAR- AND MID-TERM IMPACTS.

- TEN DOD PAYLOADS WILL BE DELAYED FROM LAUNCH DURING THE NEXT YEAR;

- THERE WILL BE A BACKLOG OF 25 TO 30 EQUIVALENT STS FLIGHTS PRIOR TO OBTAINING INCREASED LAUNCH CAPABILITY IN 1989;

- THERE WILL BE A HEAVY IMPACT ON NASA MISSIONS BECAUSE MANY BACKLOGGED DOD MISSIONS MUST TAKE PRIORITY WHEN THE FLIGHTS ARE REINSTITUTED.

IF THE DOWN TIME IS 2 YEARS, DOD WILL HAVE SERIOUS PROBLEMS WITH 21 HIGH PRIORITY PAYLOADS WAITING ON THE LAUNCH PAD FOR A LAUNCH OPPORTUNITY. DURING THIS 2 YEAR PERIOD, OVER 35 SHUTTLE FLIGHTS WOULD BE CANCELLED, REQUIRING THOSE PAYLOADS TO BE REALLOCATED TO LATER SHUTTLE MISSIONS, CONVERTED TO FLY ELVs, OR JUST CANCELLED.

UNFORTUNATELY, THERE IS NO ALTERNATIVE TO ALLEVIATE THE DOD LAUNCH REQUIREMENTS DURING THE NEXT 2 YEARS. WE MUST SIMPLY LIVE WITH THE DELAYS INCURRED.

AS YOU CAN SEE, THERE IS A GREAT INCENTIVE TO FIND THE PROBLEM AND FIX IT AS EXPEDITIOUSLY AS POSSIBLE, BUT IT MUST BE DONE CORRECTLY.

LONGER-TERM IMPACTS

UNLESS WE TAKE IMMEDIATE CORRECTIVE ACTION TO RESTORE OUR LAUNCH CAPABILITY THE LONGER-TERM IMPACTS COULD DE MUCH MORE SEVERE.

THERE ARE TWO APPROACHES WE COULD TAKE TO LAUNCH FUTURE DOD PAYLOADS. IN THE FIRST APPROACH, BY FULLY EXERCISING DOD PRIORITY WE MIGHT BE ABLE TO LIVE WITH A THREE ORBITER FLEET AS A RESULT OF OUR BUMPING RIGHTS. THIS WOULD MINIMIZE THE COST TO DOD FOR ALTERNATE LAUNCH MEANS BUT WOULD HAVE A MAJOR IMPACT ON NON-DOD MISSIONS. OR IN THE SECOND APPROACH, WE COULD OBVIOUSLY ATTEMPT TO MINIMIZE THE IMPACT TO NASA BY OFF-LOADING TO THE MAXIMUM EXTENT DOD PAYLOADS TO ELVs. THIS

WOULD SIGNIFICANTLY INCREASE THE COST TO DOD. THE OBVIOUS CHOICE IS TO ATTEMPT A MORE BALANCED APPROACH.

- THE BALANCED APPROACH WOULD MAINTAIN THE DOD SHUTTLE MISSIONS WHERE IT MAKES SENSE TO DO SO, AND OFF-LOADING SOME DOD SHUTTLE PAYLOADS TO ELVs WHERE IT ALSO MAKES SENSE. THE PAYLOADS REMOVED WOULD BE ONES WHICH COULD BE SHIFTED TO ELVs WITHOUT EXCESSIVE COSTS OR DELAYS.

THIS BALANCED APPROACH IS MOST ATTRACTIVE FROM A "NATIONAL" PERSPECTIVE. BASED ON OUR PRELIMINARY ASSESSMENT, WE CAN REMOVE SOME DOD PAYLOADS FROM THE STS MANIFEST IN THE FUTURE TO HELP NASA MAINTAIN A VIABLE CIVIL, FOREIGN, AND COMMERCIAL LAUNCH CAPACITY AND YET FULLY MEET DOD LAUNCH DEMANDS. THIS OFF-LOAD REQUIRES US TO MAINTAIN THE MANUFACTURING CAPACITY THROUGH THE MID-1990s TO:

- INCREASE THE NUMBER AND LAUNCH RATE FOR CELVs BEYOND OUR CURRENT PLAN OF 10 VEHICLES LAUNCHING AT A RATE OF 2 PER YEAR;
- CONTINUE THE TITAN II PROGRAM BEYOND THE 13 VEHICLES INCLUDED IN OUR CURRENT PLAN;
- CONTINUE THE EXISTING ELV PROGRAMS; i.e. TITAN 34D, DELTA AND/OR ATLAS;

THE DETAILS OF THIS PLAN ARE CURRENTLY BEING WORKED JOINTLY WITH NASA.

THE NEED FOR A REPLACEMENT ORBITER

DOD WILL STILL BE HEAVILY DEPENDENT ON THE SHUTTLE AND WILL REQUIRE ABOUT 4-6 LAUNCHES PER YEAR FROM THE FLEET.

DOD'S VIEW OF THE REQUIREMENT FOR THE PROCUREMENT OF A REPLACEMENT VEHICLE MUST BE BASED ON THE OVERALL MANIFEST REQUIREMENTS. HOWEVER, EVEN WITH ADDITIONAL ELVs, IT IS NOT CLEAR THAT THE CURRENT THREE ORBITER FLEET CAN MEET THE DEMANDS OF BOTH NASA AND DOD. FURTHER, THE MAXIMUM FLIGHT RATE OF THE THREE REMAINING ORBITERS MAY NOT SATISFY NATIONAL LAUNCH REQUIREMENTS.

SUMMARY

TO SUMMARIZE, MR. CHAIRMEN:

- THE NEAR-TERM IMPACT ON DOD IS SEVERE IF THE ORBITER FLEET IS DOWN FOR A YEAR. THERE IS NO "RECOVERY" OPTION THAT WILL MITIGATE THIS IMPACT WITHIN THE NEXT 2 YEARS.

- WE MUST PROCURE AND LAUNCH ADDITIONAL ELVs BEYOND OUR CURRENT PLANS AND PROCURE A REPLACEMENT ORBITER IF WE ARE TO CONFIDENTLY MEET OUR FUTURE SPACE LAUNCH NEEDS.

- WE MUST TAKE THIS ACTION NOW TO MINIMIZE THE NEGATIVE LONG-TERM IMPACTS OF THE ORBITER LOSS. IT IS OUR INTENT THAT OUR RECOVERY PLAN BE A JOINT DOD/NASA PLAN.

THIS CONCLUDES MY REMARKS. I WILL BE HAPPY TO ANSWER YOUR QUESTIONS AT THIS TIME.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

STATEMENT OF ADM. RICHARD C. TRULY, ASSOCIATE ADMINISTRATOR FOR THE OFFICE OF SPACE FLIGHT

ACCOMPANIED BY CHESTER M. LEE, DIRECTOR OF CUSTOMER SERVICES

SYNOPSIS OF STATEMENT

Senator GARN. Admiral Truly, we are happy to have you here today. We know how very busy you have been since you assumed your new post, so we especially appreciate your taking the time to come.

Admiral TRULY. Thank you, Mr. Chairman.

With your permission, like Secretary Aldridge, I would like to submit my formal testimony for the record, and make some informal comments to you.

I am pleased to be here to testify for the first time to this committee. In the role as Associate Administrator for Space Flight, I would certainly prefer different circumstances that brought me back to NASA. Certainly the challenges have never been greater.

You mentioned earlier that it is not your intention to get into the investigation as to the cause of the accident. However, I have spent a great deal of time in the last few weeks on that subject, and I would like to make a couple of comments to assure you that we are doing well.

In these few weeks, we have formed the NASA task force, we are fully supporting the Presidential Commission to study the accident, and we have made much progress in the last month.

"CHALLENGER" SALVAGE OPERATION

The salvage operations that are going on off the coast of Florida are well underway. We have located and are in the process of examining and bringing up pieces from the debris field of the right-hand solid rocket motor, as well as a good portion of debris from the orbiter. We have been working very hard in the last few weeks on the crew module itself.

These operations have, unfortunately, been delayed by bad weather and high seas. However, they are ongoing, and I think are going very well.

CAUSE OF "CHALLENGER" ACCIDENT

In recent hearings to the Presidential Commission, we have essentially exonerated as the cause of the accident the orbiter itself, the main engines, the IUS, and the tracking and data relay satellite that was the primary payload and, as recently as the 21st of this month, the external tank. Our entire effort now is essentially cleaning up some minor items on those, with major emphasis on the examination of the solid rocket motor joint. That effort is well underway.

COMPREHENSIVE SPACE SHUTTLE STRATEGY

I believe, in my job, that it is time to look forward as to how we get back to flight. Earlier this week, I issued to NASA a comprehensive strategy for safely returning the space shuttle to flight. I would like to review very quickly what that strategy is because I do think that it certainly has a bearing on this hearing.

I have divided this strategy into essentially three sections. The first, actions that we must take prior to the next flight. They are wide ranging, and a ton of work. They involve a review of our program structure and organization, a redesign, recertification, and qualification of the SRM joint, a large paper review of design requirements and certification not only of the solid rocket motors, but of all elements of the space shuttle system, and a reassessment of the launch and launch abort flight modes.

Second, I have given specific guidance for the first flight, or the next flight after the accident of the space shuttle, and further guidance as to the conduct of the first year of operations.

Finally, in this strategy, I have outlined and started an effort to build, considering all the complexities of the system, both in ground operations at the Cape, inflight planning, flight crew training, and flight controller training, a bottoms-up approach to determine what is a safe, sustainable flight rate for the shuttle.

This strategy is conservative, and it certainly emphasizes flight safety, but it is not timid. I want to assure you that under this strategy, I believe that the NASA and industry team will end up with a robust launch capability based on the space shuttle. That work is in progress.

PRESENT STATUS OF SPACE PROGRAM

In summary, I would like to give you a few personal remarks as to where I think we stand. Although our national capability has suffered a major setback and, in fact, a tragedy, I believe that we are moving forward now aggressively, with the ground rules of conservatism and flight safety, to recover, and we will.

I fully support strength and diversity in our national capability to launch payloads into space. Like Secretary Aldridge, I think our best posture is to move forward and move forward aggressively. I personally support the procurement of a replacement orbiter and, as you know, that is being discussed in the senior interagency group. That process is moving forward. I also support the Department of Defense, and a balance between the shuttle capability and their CELV development programs that are in the works.

In summary, there is much to be done, our plate is full, but we are moving strongly and, I think, in the right direction. I am pleased to be here to answer any questions that you might have.

Senator GARN. Thank you, Admiral Truly.
[The statement follows:]

STATEMENT OF RICHARD H. TRULY, ASSOCIATE ADMINISTRATOR, OFFICE OF SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Mr. Chairman and distinguished members of the subcommittee, it is my pleasure to accept your invitation to testify before this subcommittee today. This is my first real opportunity to discuss with you the activities of the Office of Space Flight and the actions that have been implemented as a result of the shuttle *Challenger* 51-L accident. We are fully committed to returning to safe shuttle flight activity and will do so as soon as we are assured that the necessary fixes are in place.

Understandably, our major energies are currently absorbed in the analysis and implications of the STS 51-L accident. The NASA 51-L Data and Design Analysis Task Force has been formed to collect and analyze information related to the accident in support of the Presidential Commission on the Space Shuttle Challenger Accident. This task force, which has four analysis teams and two support groups, is designed to facilitate the transfer of information to the Presidential Commission.

We are critically reviewing and evaluating all aspects of the program. In support of this objective, a formal reevaluation of the STS program Failure Modes and Effects Analysis [FMEA] and the Critical Items List [CIL] has been initiated. This activity is a joint review between the Office of Space Flight and the Chief Engineers Office.

Although we are still in the process of reevaluation, I believe it is important that the program move ahead with corrective actions in the areas where we are certain changes in design are required. There are several candidates for redesign consideration. I believe that the cause of the failure of STS 51-L will be identified and can be fixed and we are proceeding on that course.

My primary goal for the Office of Space Flight is that we achieve a safe and sustainable shuttle flight schedule. With the loss of *Challenger*, we have lost one-quarter of our shuttle fleet and are currently in a standdown mode. For at least the next 3 years we will be limited to a three-orbiter fleet and there will most probably be a slower buildup in flight rate than had been planned before the accident. A three-orbiter shuttle fleet and the associated infrastructure is estimated to have a flight capability of 16 to 18 flights per year. If an orbiter had to be removed from the flight schedule for an extended period of time and the Nation could only utilize a two-orbiter fleet, the maximum flight rate would then be about 12 flights per year. Even after the three-orbiter shuttle fleet is restored, there will be a significant flight capacity shortfall and a backlog of payloads which will need to get into space. There will also most probably be some slower buildup in flight rate than had been planned before the accident.

At this point in time, NASA and the administration as a whole, through the interagency process, are considering a broad range of options, including a replacement orbiter.

Production capability for a replacement orbiter varies depending upon the specific contractors or manufacturing facility. The normal build time on an orbiter based on OV-103/OV-104 experience, is about 5 years. As a result of the structural spares program, many of the long lead items, such as the aft fuselage and crew module, are nearly complete. As a result, the orbiter build time for an additional orbiter is about 3 years once we have the authority to proceed.

Although the initial planning stages have been undertaken to identify the next generation of launch vehicles with new technological capability, this capability will not be available before the end of the next decade, or shortly thereafter. Until that time, we will need the shuttle.

In addition to the shuttle, the U.S. Government does have a number of expendable launch vehicles which have been, or were being, phased out as payloads were transitioned to the shuttle and the CELV's. These vehicles, which include Delta, Scout, and Atlas Centaur, have limited capability but could be used to supplement the shuttle in delivering payloads in the near future. The DOD is also carefully looking at additional ELV's, their production, performance, and requirements for use. One of the problems we have encountered is the limited capability and availability of these vehicles and our ability to match them with current payloads. To date, we have identified two Delta vehicles which were previously assigned that could be used for other payloads if the Deltas were then replaced in a timely manner. There are three partially assembled Delta vehicles which could be used for replacement and for an additional payload sometime in 1987 or 1988. With a production turn-on, a launch readiness for the first of eight Delta vehicles could be achieved in about 30 months, with a rate of one every 2 months after that. Production of new Atlas Centaur vehicles is estimated to require 36 months and could proceed at a rate of four to eight per year. This is approximately the same length of time it would take to acquire a replacement orbiter. The combination of adequately sized shuttle and CELV fleets appears to offer the best and most effective approach through at least 1995. There should also be a promising opportunity for domestic commercial ELV enterprises, during this time, to assume both the risks and the rewards of competition in the commercial market.

Pending the outcome of the various accident-related activities, we do not know precisely when we will be able to launch our next mission and cannot accurately predict all of the related manifest changes. We have, however, established a 12-month planning baseline and prepared a proposed baseline manifest, giving first priority to critical national security payloads, then to critical scientific payloads such as the Space Telescope, or payloads with specific launch windows, and finally to other U.S. Government, foreign, and domestic commercial payloads that require the shuttle. This manifest is being worked jointly with the DOD and will be supplied for your information

Mr. Chairman, the most important step in attaining assured access to space is to identify the problems which led to the *Challenger* accident, to design and implement fixes for these problems, to assure flight safety when we return to shuttle flight activity, and to have a diversity in U.S. access to space. It is clear that we have a considerable amount of work to do before we can give you definitive answers about many of the questions you have. As we make progress in these tasks, we will make every effort to keep you well informed of both our progress and the issues to be resolved. We appreciate the assistance you have given us in the past and look forward to your continued support as we deal with these issues.

Mr. Chairman, this is the end of my prepared testimony. I appreciate this opportunity to appear before you today and would be pleased to answer any questions you may have.

FUTURE OF SPACE PROGRAM

Senator GARN. Mr. Lee.

Mr. LEE. I have no statement or comments at this time.

Senator GARN. Gentlemen, as I indicated in my opening remarks, both of our subcommittees are concerned with the impact of the *Challenger* tragedy on our ability to meet national launch requirements. That is why I emphasized that the purpose of the hearing was not to get into the causes of the accident, that is for the Presidential Commission and others. We will hold hearings on that at a later date.

Where do we really go from here? How do we move forward? What kind of a balance do we have between orbiters and ELV's?

I certainly agree, Admiral Truly, that our first priority is to restore a safe and efficient shuttle operation. I was pleased with your press conference yesterday, and I have had an opportunity to read your strategy. I think that it is well balanced.

My own personal opinion is that the announcement of nine launches the first year is somewhat ambitious. I recognize that it was only for planning purposes, and if plans were not laid, somebody would criticize you by saying: Why aren't you planning? So you can't win either way on that.

My own personal opinion, in light of what I anticipate, is it is a little overly ambitious to talk about nine launches, but again, you must plan. I really wonder, in light of what you announced yesterday, yours would seem to be, although it doesn't mention numbers, a little bit more conservative than that statement of a week or so ago. Is that correct?

SHUTTLE FLIGHT RATE

Admiral TRULY. Mr. Chairman, in this strategy, I very carefully did not mention a new launch date or a flight rate. I personally think that we are doing the right thing, and that is, find the cause of the accident, determine a design fix for that cause, look into the rest of the system now in the cold light of day, to make sure that there are not other things that we might also take this opportunity to fix in this down time and then get back on with it.

I believe that the proper thing to do is to leave in place—and it is NASA's intention to do that—the planning that you mentioned, which estimates a down time of a year, and the flight rates that you discussed. I personally don't care what the flight rate is as long as it is safe and sustainable. My feeling is that if it is not precisely what it was before, it will still be robust and the shuttle system will be a major part of our launch capability.

Senator GARN. I would agree, and that is why I wanted to bring that point out. It is fine to plan, but why worry if it is 6, 9, 11, and that is why I commend you on your statement of yesterday, to move ahead, we will fix it and make sure that it is as safe as we can possibly make it, and see what we can do within the parameters that you have outlined in setting the flight rate.

I would agree. I think you made a good decision in not mentioning the specific rate at this time.

NEED FOR FOURTH ORBITER

I think that it should be obvious to everyone that we are going to need additional ELV's. At least it is obvious to me that we need a fourth orbiter. I was one that never believed that we could fly the flight rates that were being talked about of getting to 24 a year without a fifth orbiter. So I am not sure that I understand the length of the discussion within the Administration and the Interagency Group, and why it has taken them so long. I would expect that it is OMB, with their green eyeshade accounts down there, looking at numbers, without the faintest notion about space, or housing, or anything else. They just look at numbers and have no idea of how to put priorities on things.

I would expect that that is the reason why we are having a difficult time, when Congress has essentially been willing to move ahead, recognizing the need for a fourth orbiter. Again, it would be my guess that that is probably where the hang up is, because the Air Force, NASA, and most everybody else in that group wants to, and the green eyeshade types, with their long black armbands, are sitting down there unwilling to make a commitment.

So I certainly want to express my opinion again that if we are going to have a space station and service it properly, and have the mix between the ELV's and orbiters that we do need a fourth orbiter.

Are you, gentlemen, able to comment on that, whether we need a fourth orbiter or not?

ONLY TWO ORBITERS AVAILABLE FOR DOD

Mr. ALDRIDGE. We don't have a third orbiter as far as DOD is concerned, there are only two. Only two are capable of lifting the heavier DOD payloads.

When you look at the national model, unless you want to off-load all of the potential capabilities of the orbiter back to ELV's, it is our opinion, and we strongly support the procurement of a fourth orbiter, a replacement orbiter, to be able to confidently meet the future launch demands of this country.

We cannot rule out the possibility that one of those orbiters may be down for some significant period of time. If one of those that are down happens to be one of the two that fly DOD payloads, we would be in serious trouble. So we strongly support the procurement of a replacement orbiter, as well as procurement of additional ELV's beyond that which have currently been approved by the Congress.

DOD SUPPORT FOR ELV'S

As I am pointing out, we believe that there is a need for a mix of ELV's to support both DOD, as well as the national needs for our space program. The more robust and the more capable we can make that launch posture, the better off we will be, so that if there is a problem that exists in the future, we are not faced with the same circumstances that we are faced with today, with no option, except to wait and see what happens.

Senator GARN. Admiral Truly.

Admiral TRULY. I will have to concur just about 100 percent, sir. The right thing for us to do is to have a national balance between the shuttle capability and an ELV capability. I believe that the most economical way to get that balance is to move forward with the replacement orbiter and to support the DOD in their proposals with the CELV Program.

Senator GARN. Mr. Lee, do you have any difference of opinion?

Mr. LEE. No, sir.

NEW PROGRAM COSTS

Senator GARN. The preliminary cost estimates of a replacement orbiter and other accident recovery costs total around $3 billion. We understand that DOD estimated that its cost in terms of procuring additional ELV's may total $2.5 billion.

I recognize that these estimates are preliminary and, of course, are not official budget requests of the administration, but can you give us a general idea, Admiral Truly, on the shuttle costs, and, Secretary Aldridge, what is represented in those estimates on ELV's?

Admiral TRULY. The costs of the recovery operation, quite frankly, are somewhat in doubt in my mind. For example, in the salvage operation, we have set priorities for recovery of certain elements. That is an expensive operation, and it is going to have to continue until we meet that priority, which primarily is recovery of the proper portions of the right-hand solid rocket motor.

DOD ELV COSTS

Mr. ALDRIDGE. Sir, as far as the costs of the Department of Defense, as you pointed out, we are involved in an interagency process now to determine a proper plan and a recommendation by the administration as to how to proceed.

As part of that planning process, we have looked at several options, including expanding ELV production, to give us a more robust capability in the future, to begin to work off some of the DOD backlogs that will have occurred as a result of the down time, without having to make very serious impact upon the non-DOD missions that the shuttle will fly.

As part of that plan, we have looked at expanding ELV production, modifying some of the satellites so that there will be dual compatible, they can fly either on an ELV or a shuttle, as well as some pad modifications to give us a capability to launch ELV's or shuttles from either coast.

The dollar numbers that we are thinking about are similar to the ones that you have talked about, which also include some offsetting costs in the future, but that is by far not a finalized plan at this point in time. I hope that it will be in the very near future, that we can come back in a few weeks or so, and tell the Congress exactly what our plan would be. But on that order of $2.5 billion is approximately the right number.

VISION OF SECRETARY ALDRIDGE ACKNOWLEDGED

Senator GARN. May I say to you, Mr. Secretary, that last year we had additional hearings and extensive negotiations on how many ELV's. We were on somewhat different sides of the fence, only in terms of numbers. Both of us recognized that we did need a backup capability, and the only difference of opinion was how many.

Because I put you through the hearings several times on the other side of the fence, I think that it is only fair to say that you were right, and I was wrong. I wish that were not correct.

Mr. ALDRIDGE. So do I.

Senator GARN. Because of what I put you through in some of the hearings, I felt it only fair for me to say publicly, in front of everybody, that you were on the right side of that argument. I am glad that you held me to the fire, and we at least did produce or ordered to be produced, the 10 CELV's.

Mr. ALDRIDGE. Thank you, sir.

Senator GARN. Senator Stevens.

Senator STEVENS. Thank you very much.

I don't think that it was a meaningless exercise. It gave a lot of people a chance to review the whole program, Senator Garn.

Senator GARN. I didn't say that it was meaningless. I said that I was glad that he stuck to his guns.

Senator STEVENS. I am too. I think that none of us could foresee this circumstance.

RESOLUTION OF FLIGHT BACKLOG

Mr. Secretary, it is my understanding you have testified that with the shuttle fleet at a standdown for 12 months or longer that backlogs of 25 or 30 flights can occur by 1989. We have a schedule that has been given to us, a recovery schedule on the launch program, that shows a hope of making, in fiscal year 1990, 22 flights, assuming a new orbiter is available.

I am compelled to ask you, and to ask Admiral Truly, too, if it is possible for us to pick up that rate to that point by 1990, without severely putting strain on the program that is already under stress?

Mr. ALDRIDGE. Let me address one part of it, and I would ask Admiral Truly if he would address the other part.

As far as the backlog, the reason for the variation in the number is that there is a possibility you might be able to remove or delay some of those payloads that had been manifested, and that is why I gave a range of numbers. There are some payloads that maybe are a little softer in terms of their operational needs so that they can be deferred or delayed until a later time.

That number is dependent upon what the down time is, and what the flight rate pickup might be once it gets started. There is some degree of uncertainty with that. That was just a range of numbers to indicate how severe the problem would be for the total number of missions if we were down for a year.

As to how fast we can pick up, and what is the rate of the pickup, I think that I will defer to Admiral Truly. I think that he can probably answer that question better than I.

SHUTTLE SCHEDULE ASSESSMENT

Senator STEVENS. Admiral, even before the accident, the optimum schedule had not been attained. Aren't you overoptimistic with this schedule now, in the recovery period?

Admiral TRULY. With the information available to the people immediately after the accident, I frankly think that the planning figures to get going again were correct; that is, the 1-year delay and the given buildup rates. I think that it at least allowed our system to begin to do that planning again.

My strategy that I mentioned earlier is slightly different, however, and that is to go back to our system with regard to work processing, work shifts, available people, orbiter turn-arounds, hardware deliveries and so forth, and reassess the eventual sustainable flight rate of the system. We have started to do that.

I think that it will be some weeks before we have enough data for me to answer you directly. When we have developed that sort of data, I think that we will have a much better assessment as to what we think the sustainable flight rate is. If it is different from the original numbers, I will be the first to support that new set of numbers.

NEW ORBITER SCHEDULE

Senator STEVENS. The numbers we have assume a new orbiter will be available by when?

Admiral TRULY. Fiscal year 1990 is about when it would be. As you know, we have already procured some long leadtime structural spares. Based on the OV-103 and OV-104 production experience, the time for an orbiter production from scratch, including long lead items, is about 5 years. Because, prior to my arrival, we have had the wisdom to procure some long lead structural spares, we now believe that the production time of a replacement orbiter would be about 3 years. Then with about a 6-month period, from the time it rolls out of the production facility until flight, the total time would be about 3½ years. That would be a fiscal year 1990 availability, assuming authority to proceed this year.

ELV PRODUCTION LINES

Senator STEVENS. Do we have in this plan a proposal to increase the production of the expendable launch vehicles?

I am told that the Atlas and Scout production lines are closing. The final title 34D booster is in the assembly with production terminated. The new CELV will not be delivered and launched until 1988. Is that right?

Mr. ALDRIDGE. The fall of 1988. The fall of 1988 would be the first launch of the complementary ELV that was approved last year. We are also modifying the Titan II ICBM's that are coming out of the silos that would be available to launch smaller payloads, such as the weather satellite, in early spring of 1988.

The Atlas lines, after this year, will be closing down. There are some proposals being considered by many of the contractors to extend those lines with Atlas, with the Thor, Delta, and the possibility of modifying and upgrading the Titan II and continuing production of the existing Titan 34D7. All of those are possibilities for augmentation of our ELV industry.

CELV MULTIYEAR PROCUREMENT COST

Senator STEVENS. The total CELV multiyear procurement cost is now $2.9 billion, or $800 million more than was projected last year. We are told that there is another supplemental in the works for this year of $560 million for additional ELV production. Is that right?

Mr. ALDRIDGE. Sir, let me go back to the first number. The contract cost for the complementary ELV was $2.1 billion. When we add the rest of the Government costs to that in O&M, that is the $2.9 billion.

Senator STEVENS. Yes.

Mr. ALDRIDGE. We have proposed to the Congress, which is now pending approval in the Congress, a multiyear procurement for the 10 CELV's that would save the taxpayers over $300 million over a fully funded program. That proposal is now in the Congress.

We are working on a recovery plan, as a result of the *Challenger* accident, that would expand the CELV production beyond the 10 that we currently have approval for, and that proposal is now working its way in the Interagency Group, and it should be before the Congress in the very near future.

CELV PRODUCTION RATE

Senator STEVENS. That is where I want to go. Do you have the option to increase the rate of production under that agreement for the 10?

Mr. ALDRIDGE. Sir, we can augment the multiyear contract by providing either another multiyear contract, or an augmentation of that. We are working the technical details of that.

Yes, sir, we have the right to expand the production under the same type of revision and the good deal that we got on the CELV.

VANDENBERG LAUNCH FACILITY

Senator STEVENS. There is some indication from press reports that the Air Force is considering mothballing the Vandenberg Air Force Base shuttle launch facility, and yet we have some indication that it is being planned into the shuttle launches now.

We have some 3,000 contractor personnel out there. There are no flights being planned this year. Is there any indication that we are going to be able to combine these work forces, so that we can catch up on the whole shuttle program? I am not suggesting a reduction in force as much as I am suggesting using these people in a more effective way than just waiting for launches that are not going to take place.

Mr. ALDRIDGE. Sir, we have looked at the possibility of closing Vandenberg, as well as many other options as a result of the down time that will occur as a result of the accident.

The reason that we built Vandenberg was unique. It provides a unique launch opportunity for launching into the high inclinations, the polar orbits. The reason for having that launch facility has not gone away. As a matter of fact, it has probably become stronger now. We must have that capability.

The only way, other than the shuttle, to achieve those polar orbits is to use the payloads that were planned to fly on the orbiter out of Vandenberg, and convert them to expendable launch vehicles. That would take us 3 years to do, based on the fact that the progress on the payloads has progressed to the point that they are ready to be integrated on the shuttle.

Unless we were down for more than 3 years, we could perceive no military benefit by that conversion, and it would cost us a significant amount of money to do that. It would more than offset the cost savings by closing Vandenberg to pay for that ELV conversion.

VANDENBERG UNIQUE LAUNCH FACILITY

Senator STEVENS. I am not going to monopolize the joint subcommittees' time right now, but I am concerned that it appears that the increase for shuttle operations in the President's budget, going from $634 million to $904 million, a 38-percent real growth, which was planned before the accident, I am sure we would all agree, appear to us to be primarily related to Vandenberg operations. Yet, Vandenberg also appears to be a standby facility, or a facility that is only used for unique launches.

Mr. ALDRIDGE. It is a facility that is used for unique launches, and that was the reason that we made the decision to build Vandenberg in the first place. We cannot launch the high-inclination orbits out of Kennedy. We have to have that facility in California. There is no other alternative to achieve those orbits.

ORBITER FLIGHT CHARGES

Senator STEVENS. Here is where we are going to have some disagreement with my good friend, the chairman of the other subcommittee. It is my understanding that the Air Force is required to pay the orbiter flight charge to NASA a year in advance of a shuttle launch.

Mr. ALDRIDGE. Yes, sir; that was a pricing agreement.

Senator STEVENS. Many of those launches, I know, are classified and I am warned to be careful, so I will be careful. Let me ask you this. Why do we have money in here for 1987 payments that are not going to be made?

We have money in the Defense budget now for launches that cannot take place. Why should we move that money from Defense to NASA this year?

Mr. ALDRIDGE. In fiscal year 1986, we are paying for flights in fiscal year 1987 based upon the fact that NASA needs the money at least 2 years ahead of the time to buy the components necessary for the launch.

Even though they have a 2-year leadtime, we are only paying them a year in advance. In fiscal year 1987, we also have funds for paying for the launch in fiscal year 1988. NASA needs the money 2 years ahead to begin the process.

To the extent that they have not obligated the money in fiscal year 1987, we could make that argument.

Senator STEVENS. You are going to use the vehicles now that we ordered, the expendable launch vehicles. You are not going to use NASA launches now for a while, but you are going to continue to pay for defense payloads.

Mr. ALDRIDGE. No, sir; we will fly those launches we had planned for 1987, that we have paid NASA for in fiscal year 1986, we will launch those some time, because those are payloads that will have to be flown. All NASA will do is credit us with that launch cost for a future flight. We will fly those missions. It is not a matter of getting money back. We have paid NASA for the flights, and we will fly those missions when we can.

Senator STEVENS. I will pursue it further. Thank you very much, Mr. Chairman. I appreciate your courtesy.

Senator GARN. Senator Stennis.

Senator STENNIS. Mr. Chairman, I will be quite brief. I am certainly glad that I got notice of this hearing.

NEW OPTIONS FOR ACCESS TO SPACE

Admiral Truly, in your statement you say that NASA and the administration as a whole are considering a broad range of new options for access to space. What are these options?

Admiral TRULY. Senator Stennis, obviously, our first goal, and the most important one, is to get the shuttle system operating again. For the future, we do have joint studies going for long range and follow-on systems to our present capabilities. However, for these systems, such as the transatmospheric vehicle, as an example, the technology is not going to be available until the turn of the century, or shortly thereafter, so they don't pose a solution to the difficult position that we find ourselves in today as we plan for the late 1980's and early 1990's to provide the launch capability that we so desperately need.

COST CONSIDERATIONS

Senator STENNIS. There is one other point that I want to mention. It has gone out of style, almost, to ask what things are going to cost. I know that you can't give any figures now, but we have already run out of money here, or we are about ready to run out. We have been working mighty hard here for 2 or 3 years, but we haven't gotten very far.

I am for your program, but let's crank back the idea of trying to hold down the figures. I know you are a capable man, and I have every reason to believe that those associated with you are too, but this is an expensive program.

I remember, when we started out on the road to the Moon, we were very successful. We have got to stay, but it will throw a lot of other things out of line, too. So I think that you ought to take that into your calculations, and I feel that you will. I am not trying to pin you down.

That is all I have now, Mr. Chairman.

Senator GARN. Thank you, Senator Stennis.

Senator Hollings.

Senator HOLLINGS. Thank you, Mr. Chairman.

SHUTTLE LAUNCH SCHEDULE PRESSURE

Admiral Truly, I welcome your appointment. You have done a lot to reestablish the confidence of the American people in our space program.

Right to the point of what we are all discussing here with respect to the schedule, and how many orbiters, how many ELV's, by what time, how much money. I go back to the basic philosophy and policy question of the space shuttle being looked upon as a research and development entity in contrast to a commercially viable, paying for itself kind of program and policy.

COMMERCIAL VERSUS R&D VEHICLE

In short, I want to hear from experts if the shuttle is an R&D vehicle or a commercial program? Now that we are forced to back off and look at where we are headed and what we are doing, there has been a difference between the Department of Defense and NASA with respect to what percentage of launches should utilize expendable launch vehicles to put up payloads. Perhaps the shuttle itself is too expensive a vehicle to launch regular DOD-type payloads. Furthermore, what about the commercial niche?

I hear of concern about the optimum schedule not having been reached, and we have got to move forward aggressively, and we have got to pick up the rate.

Mind you me, I like gung-ho people in the Government, people who are ready to move and do, but I want to be awfully careful I am not building up the pressure.

We had Astronaut Young himself talk about launch schedule pressure. Could some of that pressure to launch be coming from me, and from the Congress, and this committee?

Right here, at this particular time, March 1986, and talking about how it is going to be in the 1990's, are we launching on a realistic kind of schedule and program by way of policy, of commercial versus research and development vehicle?

In one short line, my question would be, do you look upon the space shuttle as a research and development program, or as a commercial program?

Just elaborate in your own words, but you see what I am getting at.

Admiral TRULY. Yes, sir.

Senator HOLLINGS. I noticed our colleague over on the House side, the other day, was saying: Wait a minute, this committee is unanimously behind shuttle launches of commercial payloads. We have got to be viable, and we have to get going in the commercial markets.

That sounds good, but in the light of the dreadful accident that we have all experienced, I want to be on the cautious side. I don't want to place unrealistic demands on NASA, and learn later on that I have launch schedule pressure of some inordinate nature. Perhaps I should be looking upon the fragile niche of the orbiter itself as a research and development vehicle still. It has only had 24 flights and it is still developing. We are now going to make some redesigns, at least to the booster rocket, and perhaps to some other parts.

Maybe the smart thing for us to do is to agree that we are just going to have to pay for this thing, and we can't just expect, commercially, to have it paid for.

I am wondering in what direction we are going and I would like to benefit, from your expertise as we reorganize now and regroup our NASA launch policy. I want to know if we ought to really be looking at launching commercial payloads on the space shuttle and making it a commercially viable venture or should it be a research and development program.

Admiral TRULY. Sir, thank you for asking that question because it does come down to the heart of what I see as a need for a practical strategy to take our system from where it is today, and get back into flight. It also touches on the very point that I mentioned earlier about directing NASA and the NASA industry people to take some actions.

It is along the line of the development of a sustainable safe flight rate. If I may, rather than put a system like the shuttle into a drawer that says, "Research and Development," or "Commercial Operation." I would like to describe to you a little bit about the direction that I have given NASA, so that we can come back to you when we have had an opportunity to take a look at it, and report with more numbers and flight rates.

SHUTTLE STRATEGY DIRECTION

If I might read a couple of sentences out of this direction, I would appreciate it:

> The ultimate safe, sustainable flight rate and the buildup to that rate will be developed in which all required work for the standard flow is identified and that work is optimized. Factors such as manifests, nonscheduled work, modifications, team workloads, work balancing between shifts, and crew training will be considered. This development will include the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting the Vandenberg Air Force Base launch site operations.

In other words, I try to be a practical person, and I find myself in a situation where we are not flying, where we have three vehicles, and whether we have three or four, we must get back to a flight schedule in a credible and economical way.

RISK IN SPACE FLIGHT

I said earlier, and I would like to reemphasize, however, that even though, as you might suspect from my background, I believe in conservatism and flight safety, I do not think that it is in conflict with a robust capability. I do not see space flight as a timid business. We will not be able to ever take all risk out of flying in space, and I don't expect that we ever will. The only way to be completely safe is to not fly at all, and to me that is too safe.

The only thing that I know to do, rather than categorize the shuttle as a commercially payback operation, or a research and development operation, would be to attempt to get from here to flight again in a credible manner. To me the most important issue in the subject of assured access to space for this Nation is to do just that: start here today, and with the best economies, and the best thinking that we can apply to the subject, get back into operation. That is what I am hoping to do.

SHUTTLE LAUNCH SCHEDULE MEMO

Senator HOLLINGS. On the commitment to launch, I think you said, in briefing our team at NASA, down in Houston yesterday, or the day before, that you had given a memo on this particular schedule.

Could you furnish the committee with the memo with respect to the launch schedule?

Admiral TRULY. Yes, sir; I certainly will be glad to do that. However, one important part of this strategy is that it doesn't dictate a launch date or a schedule. It dictates that we go back and look at our system from this point on, develop what a credible launch schedule is, come back to you and the people, and go on from there.

[The information follows:]

MEMORANDUM FROM M/ASSOCIATE ADMINISTRATOR FOR SPACE FLIGHT, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MAR 24 1986

TO: Distribution

FROM: M/Associate Administrator for Space Flight

SUBJECT: Strategy for Safely Returning the Space Shuttle to Flight Status

This memorandum defines the comprehensive strategy and major actions that, when completed, will allow resumption of the NSTS flight schedule. NASA Headquarters (particularly the Office of Space Flight), the OSF centers, the National Space Transportation System (NSTS) program organization and its various contractors will use this guidance to proceed with the realistic, practical actions necessary to return to the NSTS flight schedule with emphasis on flight safety. This guidance is intended to direct planning for the first year of flight while putting into motion those activities required to establish a realistic and an achievable launch rate that will be safely sustainable. We intend to move as quickly as practicable to complete these actions and return to safe and effective operation of the National Space Transportation System.

Guidance for the following subjects is included:

- ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT
- FIRST FLIGHT/FIRST YEAR OPERATIONS
- DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

ACTIONS REQUIRED PRIOR TO THE NEXT FLIGHT:

Reassess Entire Program Management Structure and Operation

The NSTS program management philosophy, structure, reporting channels and decision-making process will be thoroughly reviewed and those changes implemented which are required to assure confidence and safety in the overall program, including the commit to launch process. Additionally, the Level I/II/III budget and management relationships will be reviewed to insure that they do not adversely affect the NSTS decision process.

Solid Rocket Motor (SRM) Joint Redesign

A dedicated SRM joint design group will be established at MSFC, with selective participation from other NASA centers and external organizations, to recommend a program plan to quantify the SRM joints problem and to accomplish the SRM joints redesign. The design must be reviewed in detail by the program to include PDR, CDR, DCR, independent analysis, DM-QM testing, and any other factors necessary to assure that the overall SRM is safe to commit to launch. The type and content of post-flight inspections for the redesigned joints and other flight components will be developed in detail, with criteria developed for commitment to the next launch as well as reusability of the specific flight hardware components.

Design Requirements Reverification

A review of the NSTS Design Requirements (Vol. 07700) will be conducted to insure that all systems design requirements are properly defined. This review will be followed by a delta DCR for all program elements to assure the individual projects are in compliance with the requirements.

Complete CIL/OMI Review

All Category 1 and 1R critical items will be subjected to a total review with a complete reapproval process implemented. Those items which are not revalidated by this review must be redesigned, certified, and qualified for flight. The review process will include a review of the OMI's, OMRSD's, and other supporting documentation which is pertinent to the test, checkout, or assembly process of the Category 1 and 1R flight hardware. KSC will continue to be responsible for all OMI's with design center concurrence required for those which affect Category 1 and 1R items. Category 2 and 3 CIL's will be reviewed for reacceptance and to verify their proper categorization.

Complete OMRSD Review

The OMRSD will be reviewed to insure that the requirements defined in it are complete and that the required testing is consistent with the results of the CIL review. Inspection/retest requirements will be modified as necessary to assure flight safety.

Launch/Abort Reassessment

The launch and launch abort rules and philosophy will be assessed to assure that the launch and flight rules, range safety systems/operational procedures, landing aids, runway configuration and length, performance vs. TAL exposure, abort weights, runway surface, and other landing related capabilities provide an acceptable margin of safety to the vehicle and crew. Additionally, the weather forecasting capability will be reviewed and improved where possible to allow for the most accurate reporting.

FIRST FLIGHT/FIRST YEAR OPERATIONS

First Flight

The subject of first flight mission design will require extensive review to assure that we are proceeding in an orderly, conservative, safe manner. To permit the process to begin, the following specific planning guidance applies to the first planned mission:

- daylight KSC launch
- conservative flight design to minimize TAL exposure
- repeat payload (not a new payload class)
- no waiver on landing weight
- conservative launch/launch abort/landing weather
- NASA-only flight crew
- engine thrust within the experience base
- no active ascent/entry DTO's
- conservative mission rules
- early, stable flight plan with supporting flight software and training load
- daylight EDW landing (lakebed or runway 22)

First Year

The planning for the flight schedule for the first year of operation will reflect a launch rate consistent with this conservative approach. The specific number of flights to be planned for the first year will be developed as soon as possible and will consider KSC and VAFB work flow, software development, controller/crew training, etc. Changes to flight plans, ascent trajectories, manifest, etc., will be minimized in the interest of program stability. Decisions on each launch will be made after thorough review of the previous mission's SRM joint performance, all other specified critical systems performance and resolution of anomalies.

In general, the first year of operation will be maintained within the current flight experience base, and any expansion of the base, including new classes of payloads, will be approved only after very thorough safety review. Specifically, 109 percent thrust levels will not be flown until satisfactory completion of the MPT testing currently being planned, and the first use of the Filament Wound Case will not occur with the first use of 109 percent SSME thrust level. Every effort will be made to conduct the first VAFB flight on an expeditious and safe schedule which supports national security requirements.

DEVELOPMENT OF SUSTAINABLE SAFE FLIGHT RATE

The ultimate safe, sustainable flight rate, and the buildup to that rate, will be developed utilizing a "bottoms-up" approach in which all required work for the standard flow as defined in the OMRSD is identified and that work is optimized in relation to the available work force. Factors such as the manifest, nonscheduled work, in-flight anomaly resolution, mods, processing team workloads, work balancing across shifts, etc., will be considered, as well as timely mission planning, flight product development and achievable software delivery capability to support flight controllers and crew training. This development will consider the availability of the third orbiter facility, the availability of spares, as well as the effects of supporting VAFB launch site operations.

THE BOTTOM LINE

The Associate Adminstrator for Space Flight will take the action for reassessment of the NSTS program management structure. The NSTS Program Manager at Johnson Space Center is directed to initiate and coordinate all other actions required to implement this strategy for return to safe Shuttle flight.

I know that the business of space flight can never be made to be totally risk-free, but this conservative return to operations will continue our strong NASA/Industry team effort to recover from the Challenger accident. Many of these items have already been initiated at some level in our organizations, and I am fully aware of the tremendous amount of dedicated work which must be accomplished. I do know that our nation's future in space is dependent on the individuals who must carry this strategy out safely and successfully. Please give this the widest possible distribution to your people. It is they who must understand it, and they who must do it.

Richard H. Truly

FISCAL YEAR 1986 SHUTTLE SUPPLEMENTAL

Senator HOLLINGS. I hate to use the expression "save money," but there is no better way, since we have been delayed and we haven't the expense of the launches that we normally had scheduled this year. Yet at the same time I realize there are also expenses since we have to keep the personnel and teams together for missions that were to have been launched. On balance, did we save money or lose money, and are we going to have the same budget?

There are some who are looking at it from the Budget Committee standpoint, that we are not going to have all those launches, and we are not going to have all these expenses, rather than increasing the budget, here is a place where we can save. I want your comment on that. Are you going to ask for a supplemental this year?

Admiral TRULY. There is a supplemental that is in the works in the Interagency Group. It has not gone to the President yet, and I am sure that it will be forthcoming, if he makes that decision.

This is undoubtedly an expensive business. It always has been, and it always will be. Recovering from an accident such as we have experienced is going to cost this Nation money, be it additional money or be it from programs that were previously planned.

I am a novice at that business, but I think we all recognize that. As Senator Stennis pointed out, the budgets and economies of this situation are extremely complex, and we must all, I think, face up to them together. I see no other way to proceed than to try to take our situation from where we find it today, and have a practical, reasonable recovery plan that recognizes that we have had an accident, that we do need to look at our business and at our system. We plan to do that.

Senator HOLLINGS. Thank you, Mr. Chairman.

Senator GARN. Senator Domenici.

Senator DOMENICI. Thank you very much, Mr. Chairman. I will try to be very brief.

SHUTTLE REPLACEMENT DECISION

I assume that both of the witnesses would agree that as the future presents itself in light of the accident, the first thing we ought to do as soon as possible, is decide what we are going to do about replacing the shuttle, and what the timeframe is for its replacement and resuming the shuttle missions.

Don't you agree that we ought to get that decision made as soon as possible?

Mr. ALDRIDGE. I would agree with that, yes, sir.

Admiral TRULY. Yes.

Senator DOMENICI. It seems to me, from what I have read of your testimony and elsewhere, that obviously we are talking hypothetically in terms of how long it might take before the shuttle is replaced and the missions are resumed. We have to find out what caused the accident, and once we know that, what may be necessary to supplement the previously planned civilian and defense programs. Is that correct?

Admiral TRULY. Yes, sir.

ADDITIONAL CELV REQUIREMENT

Senator DOMENICI. On page 5 of your testimony, Mr. Secretary, you outline an approach, and I guess it would be called a balanced approach, to maintain the civilian space program and meet the demands of the Department of Defense.

How many additional CELV's would you estimate will be required to meet DOD short-term launch demands? Could you also tell us what your answer is predicated on in terms of the first question that I just asked?

Mr. ALDRIDGE. Senator, I can't give you a specific answer, and the reason is that we, in the Administration, have not come to a final solution. We are in the process right now, which is coming very near to closure, of an interagency study that the Senior Interagency Group on Space will address the first part of April.

What that plan includes is a series of options, looking at replacing the orbiter, not replacing the orbiter, augmenting with ELV's, not augmenting with ELV's. All of those options are being considered in the Interagency Group.

The preciseness of the numbers, the amount of the supplemental, all have to be passed by that group, and ultimately approved by the President before it would come over here.

However, the general kind of direction that is coming includes a general consensus that replacement of the fourth orbiter appears needed. The augmentation of the expendable launch vehicle program, over and above that which was approved by the Congress last year, is needed. It is a matter of working the details of how much funding do we need, what is the procedure for funding, and some of the other smaller level details that need to be done.

As my testimony said, I believe that that process is coming to an end, and it will be ending in the next few weeks. Once the President makes a decision on how to proceed, we could come back and explain to you in detail what that plan would be.

Senator DOMENICI. You have not given an estimate of that before?

Mr. ALDRIDGE. Other than options that are concerned in that Interagency Group. The Congress has approved the expansion of the Complementary ELV Program for 10 vehicles, and a modification of the existing Titan II ICBM's to space launch vehicles that was approved last year, and some moneys were approved in fiscal year 1985 for that. We are looking at options that would probably double that number over the next 5 years. The preciseness of the details, I am a little premature in explaining exactly what they are until that Interagency Group meets and approves the Administration's plan.

Senator DOMENICI. A portion of that change will be, in your opinion, borne by the Defense Department. Is that not correct?

FUNDING OPTIONS

Mr. ALDRIDGE. Part of the issue is exactly what is the mechanism for funding. Our view of this as a national emergency, if a supplemental is required to augment for a national emergency, it ought to be a supplemental. We are looking at different kinds of options for funding. I can't predict what the President will decide as to how that program will be funded.

Senator DOMENICI. Mr. Chairman, I ask the question, because while this is an emergency, and while it may ultimately be less than relevant as to what part of the Government the money comes from, I think you are aware that, at least in the Senate, we have followed your recommendation. The Senate version of the fiscal year 1987 budget resolution accommodates in the general science and space function, in a fenced manner, contingent upon the enactment of an authorization bill, the rebuilding of the shuttle orbiter. The Senate budget resolution assumes $976 million. I think that it is in budget authority, and $703 million in outlays in the first year, and the full $2.7 billion in budget authority and $2.4 billion in outlays over the 3 years.

The only point I am making is, obviously, that amount will not take care of any extra CELV's that have to be developed because of the time delay in launching the military payloads.

Senator GARN. Yes; I am aware of that.

Senator DOMENICI. Just one last question.

SIZE OF SHUTTLE-CELV FLEET

Admiral, on page 3 of your testimony, you state that, "A combination of adequately sized shuttle and CELV's appears to offer the best and most effective approach, at least through 1995." If you already answered this before I arrived, don't repeat it, but what is your best estimate of an adequately sized shuttle and CELV fleet?

Admiral TRULY. Chet, would you mind.

You caught me at a bad time.

Senator DOMENICI. Surely, it could not have been the question, it must have been the water.

Admiral TRULY. No, sir.

Mr. LEE. I think Secretary Aldridge indicated that they are looking at various options, and he indicated one option, which we have looked at, and this planning manifest involves something like doubling the ELV's that had been approved previously, which is essentially offloading something like the equivalent of 14 shuttle flights through the period of 1992 with DOD payloads.

CELV FLEET

Senator DOMENICI. Doubling the CELV fleet, and what is that fleet planned for now, how many?

Mr. ALDRIDGE. We have 10 approved in a multiyear proposal that is before the Congress through 1992. What we would propose, at least for consideration in this Interagency Group, is roughly to double that over the next 5 years, to take up some of the payloads from the shuttle flights that can be flown relatively easily on CELV's.

Senator STEVENS. Would the Senator yield there?

Senator DOMENICI. Of course.

CELV FUNDING SOURCE

Senator STEVENS. The Senator should inquire how much of that money is in the defense budget as opposed to NASA, that is the key issue.

We have two subcommittees. The Senator's budget did take care of the NASA portion, but the defense portion of what the Secretary and the Admiral are talking about is not taken care of in the budget, as I understand it.

Senator DOMENICI. I believe it could be. Let me put it this way. I believe you might take care of it as the appropriator, but you would have to reduce something else. I think that it is a fair statement. I am not suggesting that you can or should, I am merely saying that that could be an option.

Senator GARN. Would the Senator yield on that point?

Senator DOMENICI. Of course.

LACK OF DOD FUNDING

Senator GARN. Senator Gorton, and I discussed it with him, as the authorizing committee chairman, and that language was included. I am a member of both subcommittees, and I am chairman of this one. I am also a member of the Defense Appropriations Subcommittee. I guess that was a function of where Armed Services should have been, in requesting the authorization, seeing that it was in the budget resolution. But that DOD part is not taken care of.

Mr. ALDRIDGE. No, sir; there are no funds for this augmentation of the ELV's, or any of the modifications of the payloads necessary to make them fly. None of that is now included in the defense budget.

Senator DOMENICI. On the other hand, so I understand what we did, nobody has asked the Congress for such funds in any official way as of this moment; is that correct?

Mr. ALDRIDGE. That is correct, sir.

DOD FUNDING REQUIREMENT

Senator DOMENICI. How much would that cost, just so we have that one on the record. Is that the $2 billion estimate?

Mr. ALDRIDGE. For the defense, sir?

Senator Domenici. For the defense part of doubling the CELV's.

Mr. ALDRIDGE. Over the next 5 years, roughly $2.5 billion.

Senator DOMENICI. Thank you very much.

DOD BUDGET AMENDMENT

Senator HOLLINGS. What should have been included in that budget for DOD that we didn't ask for?

Senator DOMENICI. At this point, as I understand it, Senator Hollings, if I might, they are merely saying that a decision has not been made as to whether they will double the CELV fleet, and the budget resolution does not assume such funding, as the distinguished Senator from Alaska asked. I merely clarified that there is no official budget request at this point either.

Senator HOLLINGS. Then you and I can put in an amendment when we discuss the budget later in April, when we come back.

Senator DOMENICI. We could.

SIG DECISION

Senator GARN. We would hope that the SIG would have finally made a decision. They have been dragging their feet. You were not here when I complained about OMB. NASA and the Air Force, as part of that group, know what their recommendation is, but the green eyeshades down at OMB are the ones who have been holding up the SIG. So we would hope that by the time we come back, the administration does have a recommendation in both areas. I personally hope that it would include a fourth orbiter and an adequate number of ELV's to keep that balance.

Senator Lautenberg.

Senator LAUTENBERG. Thank you, Mr. Chairman.

I want to add my welcome to those who joined us this afternoon because you bring a particular point of view that is very important for us to review as we discuss our responsibilities to the space program.

BALANCE BETWEEN CIVILIAN AND MILITARY NEEDS

One of the questions that arises for me is the balance between the civilian and military needs. The bumping process, as you mentioned, Mr. Secretary, is one that gives you priority rights. Unfortunately, we don't have the available resource to take care of both sides of our needs.

We do have the national security requirements in space—meteorological, navigational, communications—but we also have some SDI research that is funded in here, and we can't ignore the civil and commercial missions that we have to continue to promote, to advance.

So, if you exercise your bumping rights, what does that do to our ability to conduct the launches that we need for civil and commercial purposes?

Answer this for me before you answer the other question. Have you discussed your schedule of launches between now and 1989? Have you mentioned the number that you require?

DOD IMPACT OF SHUTTLE DOWN TIME

Mr. ALDRIDGE. No, sir, I haven't. I have mentioned that if we are down in the orbiter flight for 1 year, we will have 10 DOD missions not flown, that will be ready on the launch pad to fly once we start.

Senator LAUTENBERG. That is 1 year

Mr. ALDRIDGE. A 1-year down time. If we were down for 2 years, we would have 21 DOD missions waiting to fly once we start flying again.

Senator LAUTENBERG. Now, Admiral Truly, your requirements as you see them call for how many launches over the next few years that you think are essential to maintain our space program?

Admiral TRULY. If I might, I will ask Mr. Lee, who is in manifesting, to answer that specifically. Before I turn to him on the numbers, let me say that you have touched on a point that is of great concern to us. That is, even though it is nothing new for our national security requirements to take first priority where they must, we certainly do find ourselves in a difficult position now as we try to get back to flight, and to balance those requirements against other expensive and important requirements that range from planetary missions, Spacelab missions, and the commitments to the launching of our commercial and foreign satellites.

The difficulties are certainly there, and we are going to have to face them. The longer that we are down, the tougher it is going to be. It is a very complex process. However, I might point out, as Secretary Aldridge said earlier, of the three orbiters that we have, most of the Department of Defense payloads cannot be flown using the Columbia OV–102 because of their payload characteristics and primarily their weight. Therefore, I believe that once we can get a practical program going again, within certainly a year to 18 months, I personally believe that we will have served each of the classes of our customers. If we can get a replacement orbiter and the CELV initiatives that Secretary Aldridge has mentioned, I believe in a few years, we will be back meeting our full requirement by early 1990's. That is what we jointly recommend.

If I might, at this time, ask Mr. Lee to comment about the numbers of satellites that we will miss with a 1-year down time or maybe a little farther.

NATIONAL SECURITY PRIORITY

Mr. LEE. Senator Lautenberg, if I may just take a moment to explain that national security priority doesn't necessarily mean that we can manifest each flight sequentially and give the flights to the Department of Defense. There are many constraints that prevent this.

It is the airborne support equipment, the need of the particular payload that the Department of Defense is projected to launch, plus the priorities of NASA's payloads. The DOD has been very cooperative on this, and not all of their payloads are forced to the front of the line.

We have been able to mingle the priorities of NASA payloads, such as the planetary, which Admiral Truly talked about, as well as the TDRS, which is fundamentally important to the data system for the shuttle and the science payloads. In doing this, we have been able to accommodate the various priorities, including using OV–102, as Admiral Truly talked about, to take care of a payload like the GPS, the NAVSTAR satellite system, which is a high priority, and add some communication satellites, because the 102 is a beautiful vehicle for that. We can take care of some of the commercial customers in that fashion.

For example, in the first year of operation, the commercial communication satellites take a hit in the sense that we only get about two or three of those up, but the split is between the Department of Defense and NASA. We have about two to three a piece on those. That percentage, in the following year, is somewhat the same. It is something like four to five equivalent flights for NASA, around 5.5 flights for the Department of Defense, and about 2.5 equivalent flights, and that may be five or six commercial payloads, for the commercial field. So we are getting a mix.

The bottom line comes out that the Department of Defense does increase and get the preponderance of flights. The percentage goes up to perhaps, in some years, a little over 50 percent of the available flights until they catch up with their backlog. The NASA prime science gets a smaller percentage, and then following that comes the routine NASA science and commercial payloads.

SHUTTLE LAUNCH CARRYOVER

Senator LAUTENBERG. The fact of the matter is that as DOD makes its requirements felt and pushes the schedule, then we are going to be suffering substantially, as I understand it, from the planned launches that you have. I have a figure of some 24 launches planned by NASA through 1989. Does that sound like a reasonable number?

Mr. LEE. I think you are referring to a carryover of approximately 24 flights if we went back to the preaccident schedule. The number of flights we had scheduled through fiscal year 1989 up to 1990, I think, was on the order of 73 or 74. We are currently projecting—planning, I should say, from Admiral Truly's point that he is going to look in to that. We are planning on the order of 40 flights, or 45 flights, so there is a differential there.

I would only say that that was on the flight rate that was projected. Not all of those cargo bays were filled prior to the accident. In the 1989–90 timeframe, there were a number of payloads where the bays were not filled. We didn't have them filled with DOD or NASA payloads because of the budget projections, or even with foreign and commercial communication satellites because we normally don't get those people until about 3 years before launch.

MINIMIZE CROWDING-OUT PROBLEM

Senator LAUTENBERG. If we look at the budget proposals we see that NASA's share of space exploration funds continues to diminish relative to the total program, and certainly relative to DOD. Then we face the crowding out problem. We face, I assume you will agree, enormous disadvantage in our competition for commercial opportunity, as well as scientific advantage that we have to continue to maintain, by not only the limitations of resource and horrible accident that took place, and the delays associated with that, but also by DOD needing help in launching its vehicles.

Are we going to be suffering substantially in the civilian side of our space program if we try to make available the launch capacity to DOD that we have?

EFFECT OF DOD PRIORITY

Mr. ALDRIDGE. I think that the answer is, yes, the civilian and commercial payloads will suffer as a result of the down time and the DOD priority that will occur in the early years. We will work with NASA to try to minimize that, but, Senator, we have no alternative for the first two years. There is no other solution, other than to live with what we have.

Now, our recovery plan and strategy is, over the longer term, to try to minimize by offloading some of those payloads that can be easily offloaded on the ELV's, that don't require a lot of cost and a lot of delay time, and do not require manned systems. We can offload those into ELV's and, therefore, minimize the longer term impact to NASA, and get them back upon a bigger percentage of civil and commercial ventures.

As a matter of fact, what our plan would look like, we would return to about one-third of the available shuttle flights as are currently planned. We are committed to one-third of the shuttle flights. As the flight rate builds up to something in the future, whatever that number will be, we will still be in that range.

I think our plan begins to solve the problem, but there is no alternative, other than not flying those DOD payloads in the near term.

Senator LAUTENBERG. My time is up, but just to clarify. You said that it was budget and DOD priorities that caused the imbalance. I am not criticizing, but I just want to be sure about that.

Admiral TRULY. And the position that we found ourselves in with the loss of capability, all areas are going to suffer until we can recover the capability of the shuttle fleet.

Senator LAUTENBERG. I understand.

Thank you, Mr. Chairman.

DEFENSE BUDGET

Senator STEVENS. Could I pursue one question, I am going to leave.

The comment that was made here about trying to balance the civilian loss of lift now with NASA and with the military. As I look at this, the Defense budget has become the insurer of the transition period. We are going to use the expendable launch vehicles we provided for last year, and we are going to order some more. Meanwhile, it doesn't seem to me that there is too much pinch being put on the commercial side and on the NASA side of these lifts.

I want to echo what has been said here. Senator Stennis and I have the problem, and the other members who are with us, in terms of the Defense Subcommittee, but the Defense budget that is coming out of the Budget Committee is really low. There is not room in there for any more insurance for the space program unless we cut some other very high priority defense missions, or cut people, cut standing military which we don't think we can afford to do at a time like this.

NASA BUDGET

I think that somehow or other, NASA has to look at its budget in this interim period and find some ways to save money. We are not saying that they have to lay off the experienced people that they need when these liftoffs commence again, but it does seem that Vandenberg coming on the line now, and the other people that you have that are all there for launches, that are not going to be taking place for over a year, that there ought to be some room for some savings. We are being hard pressed to make savings.

I hope that you will give us some indication of where at least part of this supplemental that is going to be submitted to us can come from existing programs. In other words, you suggest to us where we can reprogram funds to meet this new level. Our subcommittee is criticized all the time for appropriating money for emergencies that were not authorized. You have one. By the time yours gets up here, the authorization bill is going to be on its way, and there is going to be another fight if we put money in there in an area that is not authorized. We are going to face that back just as soon as we get back from Easter recess.

I want to urge you to really scrub your budget and see if there isn't some way that a portion of this interim expense can be taken from the NASA program. The military missions are going ahead at cost to the defense budget without shuttles, as I understand it.

ELV'S FOR NONDEFENSE PAYLOADS

Are you going to use any of these ELV's for nondefense liftoffs in the next year?

Mr. LEE. Senator Stevens, the additional ELV's that Secretary Aldridge talked about are not coming into play until 1989 and beyond.

Senator STEVENS. I know, but we have some in reserve now.

Mr. LEE. There are no ELV's available at this time, and the numbers that I have discussed were based on the next 2 or 3 years before the ELV's even come onto the scene to take some of the load off.

FISCAL YEAR 1987 NASA EXPENSES

Senator STEVENS. We are talking about 1987. The budget that we are talking about is 1987 and 1988, we are not talking about 1986, I understand that. I am talking about fiscal year 1987. Those expenses, if you are not going to have any shuttles lifting off, and it doesn't sound like you are to me, those NASA expenses, in my opinion, have to be reviewed to see whether they are absolutely essential to maintain that level of activity until you can get back into the shuttle business.

Senator LAUTENBERG. Would the Senator yield?

NASA FUNDING FOR CELV'S

Senator GARN. If I could respond, I may know a little bit more about the budget than Admiral Truly does at this point, having just come on board.

I will repeat, Senator, I am the chairman of this subcommittee, and a member of the Defense Appropriations Subcommittee, and you don't find any more hawkish Senator than I. I have a 12-year voting record to prove that, of being in favor of defense. But to ask NASA to come up with a share of the CELV's at this point—we fought last year. The budget cutters, originally, were cutting NASA below a freeze level. They picked the low of the low going in, and we ended up down around $7.4 billion. We were finally able to get it back up to about $7.7 billion, which was $200 million under the President's request, just barely above a freeze level.

Then with the March 1 cuts under Gramm-Rudman, we are back down to about $7.35 billion. We are not maintaining a freeze level. As much as I am a defender of defense, out of a $295 billion, or $265 billion, or wherever you go, to ask out of a $7.5 billion budget, which only a little more than half of that is space related—four-tenths of 1 percent of the national budget for space, seven-tenth total NASA budget—to say that we are going to find that, after we have taken a $350 million hit under Gramm-Rudman, out of the budget that we fought so hard to get just barely above a freeze level, it isn't there.

You cannot terminate those launch teams because we are going to stand down for 1 year, and then expect to get them back. They are not going to be there. You don't hire that kind of people.

So as much as I would like to be helpful and want to go in both directions, I think we might say to Defense, we need to find that $2.5 billion for their cargoes.

AIR FORCE-NASA FLIGHT AGREEMENT

There is another thing that needs to be said about this mix between military and civilian cargo. It has been less than a year that we were hammering out that agreement to get the Air Force to pick up eight flights per year——

Mr. ALDRIDGE. That was not a forcing, Senator, we were going to fly 9 or 10. We just agreed that we could commit to at least that.

Senator GARN. It was a guarantee.

Senator LAUTENBERG. With a little pushing by the chairman, I think, if I remember.

Senator GARN. Yes, it was a guarantee so that we helped the shuttle be viable, that at least a specific number of DOD payloads would go per year. So we can't play that one both ways either when we are trying to force DOD to agree to at least that minimum number, and then we come back and say, now we are too dominated by DOD. It has to be one way or the other.

The Senator from New Jersey is correct, in order to have an integrated space program that is still run by civilians, and not by the Air Force—I am a retired Air Force officer, too, so I have a hat in every ring around here—we wanted to have that balance between the shuttle and the CELV's, a balance between NASA and DOD, with NASA controlling as the civilian agency, and not letting the Air Force have their own space program.

Things have changed because of the accident.

Senator STEVENS. Let me see if I can finish this, because I do have to leave and go to the floor. I don't object to the Senator's statement, but the problem really is, we have all just heard that NASA's budget is included in the new budget. The Defense money is not in the budget. It means, as the chairman said, that we are going to have to take something out of what is left of the Defense budget to finance Defense space requirements.

VANDENBERG O&M COSTS

I am not just going after NASA. I still would like to ask more questions about Vandenberg. Vandenberg is going to cost $400 million a year to keep open, with no opportunity to have any launches.

Mr. ALDRIDGE. Your question about finding ways to cut, we are going back to take a look at that. The $400 million a year was the O&M costs, assuming four flights per year out of Vandenberg. That, clearly, is not going to occur until at least we get a fourth orbiter back on the line.

Senator STEVENS. I would like to have that figure if we have the wrong one.

Mr. ALDRIDGE. We will take a look at that.

Senator STEVENS. I have been told that mothballing Vandenberg could save as much as $400 million a year.

Mr. ALDRIDGE. No, sir. You cannot just walk away from that facility and leave it like it is. Some amount of that money would have to be kept for mothballing and keeping some facilities going. We don't know exactly what that number is. Also, once you close it down, it would take us 3 years to restore it. So the idea that we ever thought that we were going to bring Vandenberg back on line, which will be required for the space station and for SDI, and additional DOD missions in the early 1990's, we would essentially close it for a couple of years and bring it right back on line again, the cost to do that is very substantial.

The alternatives of paying for shifting the payloads that would then have to fly ELV's out of Vandenberg more than offset the cost savings that you have just referred to.

BUDGET CONSIDERATIONS

Senator STEVENS. I would like to see that, and we will have more questions for the record.

Mr. Chairman, I think that the table is going to be turned this year. We are the ones who are under the gun as far as the budget is concerned, and I am going to be unwilling to add extra cost for NASA in the defense budget this year unless it is absolutely proven to be necessary.

Senator LAUTENBERG. If the Senator would yield for a second for one comment, because I heard an interpretation from the Senator from Alaska, whose knowledge and interest I respect, that was different from that which I heard from the witness table, and that was, I thought, the Senator said that there should not be a serious impairment to the civil side of the launch program, and I think that all of you agree that it would be impaired regardless of what the budgetary situation is, based on what we are planning now for DOD needs, including budget availability.

Am I correct in that? I must point out that while the DOD portion of the space activities, in constant dollars, has gone up twofold, and slightly more, in 20 years, and the NASA side of things has gone down by roughly two-thirds in the same 20-year period, from 1965 to 1985.

So what we have seen is a definite shift, and this is not taking sides. I do support the space program—absolutely. It is essential if we are to maintain our leadership in many areas, but I think that we ought to recognize that the DOD program is at the expense of some of the civil and commercial exploration and launch programs that we have.

Mr. ALDRIDGE. Sir, I think that the answer to that is that we have no other solution over the next 2 years. That will, in fact, be the case.

Senator LAUTENBERG. You may drive us to a solution which I think may not be desirable.

Mr. ALDRIDGE. What Senator Stevens was getting to, over the longer term, to try to minimize that impact upon the civil functions, we are converting to ELV's. So we are using the defense ELV's to minimize that impact for the future.

Senator LAUTENBERG. But Chairman Garn's point was, when we had that hearing last year at just about this time, it was to try and reduce the overhead costs of NASA, while at the same time accomplishing what the DOD needs were, and not to be developing any interdepartmental rivalries, but rather to try and work as efficiently as we can. I think that the point was well made at that time, and I think that it is appropriate to bring it up again.

Thank you, Mr. Chairman.

Senator GARN. Senator D'Amato.

Senator D'AMATO. Thank you, Mr. Chairman.

CENTAUR COMPATIBLE ORBITERS

Mr. Chairman, it seems to me that when the *Challenger* was one of only two shuttle orbiters capable of carrying the upper stages needed to launch satellites to geosynchronous orbits of 22,000 miles, the loss of *Challenger* means that we only have one orbiter which is Centaur-compatible, that remains in the fleet, and that is the the Atlantis.

If that is the case, the Atlantis is our only Centaur compatible orbiter right now, how does this complicate our recovery planning?

Admiral TRULY. May I make a comment?

Shortly after the accident, and prior to my coming on board as the Associate Administrator for Space Flight, authority was given to move out to modify the Discovery such that the Discovery and the Atlantis would be Centaur capable. By the time we get back into flight next year, we should have two of the vehicles that would be modified for the Centaur to be capable to fly.

The Columbia, the third remaining shuttle, was the first orbiter, and it is not economically feasible to convert it to carry such heavy payloads.

Senator D'AMATO. What would be the cost involved and the length of timeframe for that kind of modification?

Admiral TRULY. I believe that the number that we authorized was $5 million to configure the Discovery. I am not familiar with the schedule enough to know months, but I know that it will be accomplished by the time that that vehicle is ready for flight again.

Senator D'AMATO. Do you see this as an absolute necessity?

Admiral TRULY. Absolutely, sir.

Mr. ALDRIDGE. We support that, Senator, very strongly.

Senator D'AMATO. I would think it is, because that is the only way that you can get these satellites up out of the atmosphere, free from Soviet attack, is that right?

Mr. ALDRIDGE. We have two upper-stages that are capable of launching satellites into geosynchronous orbit. Centaur is one of them, and the inertial upper stage is the other.

CENTAUR FLIGHT SAFETY

Senator D'AMATO. It has been reported that Centaur was a serious flight safety issue prior to the *Challenger* accident, and that the entire program is being viewed with increasing—let's say that it is being reviewed. Is Centaur too volatile to carry into orbit?

Admiral TRULY. Again, if I might comment on that. In light of the *Challenger* accident, we are looking at the entire system with regard to flight safety. It is our intention to apply the same sorts of criteria for safety to payloads and upper stages as we do to the orbiter itself, no more, no less.

Centaur will certainly come in for scrutiny, but I want to assure you here that we are moving out to continue to prosecute that program, and we have every intention to examine it just as carefully as we are examining the solid rocket motors, and the orbiter itself. If changes are justified, we will make them. But I have no reason to suspect at this point that we have a problem with Centaur that is not manageable within this same criteria that we are applying to the basic vehicle and that is to make sure that the risk to total loss of vehicle or crew is absolutely minimized.

DUAL LAUNCH COMPATIBLE SATELLITES

Senator D'AMATO. Given the *Challenger* accident, what initiatives does the Air Force propose to undertake to make more of its satellites dual compatible, capable of launch from either the shuttle or the CELV's?

Mr. ALDRIDGE. Part of our Interagency Group study is looking at exactly that philosophy. I can assure you that we are very interested in pursuing a dual compatibility for those spacecraft that we can do so easily and without a great deal of expense.

There are some payloads that are designed for the shuttle, and the cost and delays to modify them to go on an ELV would be prohibitive. For those payloads, we would plan to continue to commit to the shuttle for flying them. There are other payloads that can be moved to ELV's, and those that can be moved and made dual compatible, so that we are not dependent on either the ELV problem, which we know we have had problems with in the past, or a shuttle. We can shift from either launch capability.

We are looking at that for the future of our design. I put that high on our priority list for the future.

Senator D'AMATO. Thank you very much, Mr. Chairman.

Senator GARN. Senator Stennis, do you have any additional questions?

Senator STENNIS. No, thank you, Mr. Chairman.

Senator GARN. Let me make a comment, getting back to commercial cargoes, and so on.

COMMERCIAL CARGO FUNDING

Over a number of years, we have always had the ongoing debate over some in Congress who wanted to have full pricing for commercial satellites. I have always resisted that because with the subsidized competition in the area, and it seemed to me that there would be no additional money for the support of the shuttle system. Simply all of the commercial cargoes would go to the Ariane, and you wouldn't have any.

I have felt all along that whatever we could reasonably get for launching commercial satellites was an offset to the taxpayers for the cost of the shuttle, and the primary use of the orbiter in my opinion was not the value in delivering satellites into space in any event, but scientific research and development of vehicles to get back and forth from the space station. I still feel very strongly that way as I hear the debate going back and forth about particular cargoes.

I personally can still justify the cost of the shuttle, a relatively small part of the total space flight budget, as I mentioned, four-tenths of 1 percent of the total national budget, when I start looking at the pharmaceutical area, and what I expect will come from microgravity for production of pharmaceuticals and medicines, things of that nature that I don't think we talk enough about.

We always end up in these hearings almost always talking about a physical satellite being placed into orbit. Yes, we can go back and fix it, yes, we can repair it, we can retrieve it, as opposed to an ELV, and that is an additional argument.

There is no doubt in my mind whatsoever that if we had decided to do that, you can always put a satellite into orbit more cheaply on an ELV than you can on orbiter. I will grant that to the Flat Earth Society members, and those who are opposed to manned space flight.

Somehow, we have got to communicate the value of this space transportation system in terms of far greater value than just delivering a satellite into orbit.

I hope that as we proceed with this, we recognize that we require satellite capability, and that the first priority has to be defense satellites. When we talk about the cost of defense doubling—and I mentioned this earlier in the hearing today—that is misleading unless we define what defense is doing in space.

SKY SATELLITES

It is not weapon systems; it is communications satellites, it is navigation satellites, it is spy satellites, which we needed after losing the sites in Iran, and if we ever hope to have a reasonable arms control treaty that we can sign, we had better not sign it unless it is verifiable.

Some people want to just condemn DOD in being up there at all. Some of those who want arms control treaties the most had better hope that we put those spy satellites up there so that we can verify those treaties.

I think that this is an important point to be made of what you are putting up there, without getting into the black boxes and the security clearances of exactly what they are doing. That is what we are putting into space for the Department of Defense, for the security of this country is either totally defensive in nature, or is helpful to our ships and to our airplanes in providing navigational assistance. When I think what we can do now with satellites compared to the way I used to navigate with a sextant across the Pacific, I wonder how I ever survived, getting back and forth with a drift meter and a sextant, reading drift meters off the wave height, and sun lines for speed lines, and all that sort of thing.

Just because it is a DOD cargo, I think we need to know what is going on up there. I am sure that all of you gentlemen would agree with that. I don't think that we can say, "Look, DOD is dominating," because a lot of those vehicles are also very helpful to the civilian sector of our economy as well.

Admiral TRULY. Sir, I would sign up to that speech right away. I concur in all of it.

SUBMITTED QUESTIONS

Senator GARN. Gentlemen, we have some additional questions, quite a few, which we would like to ask you to respond to in writing. We didn't want to close the session today to get into some classified areas. So I have no additional oral questions for you today.

Are there any closing remarks that any of you would like to make?

Admiral TRULY. No, sir.

Senator GARN. Your testimony has been very, very helpful. We thank you very much for being here today.

Admiral TRULY. Thank you, sir.

Mr. ALDRIDGE. Thank you.

[The following questions were not asked at the hearing but were submitted for response for the record:]

NASA RESPONSE TO QUESTIONS

QUESTIONS SUBMITTED BY SENATOR GARN

Shuttle/Centaur

NASA is engaged in a comprehensive review of the entire Shuttle system including detailed re-examination of all critical items. Concern has been expressed over the planned use of the Centaur-G upper stage, since it uses liquid hydrogen and oxygen as a propellent and, therefore, is more technologically complex and demanding than other storable upper-stages.

Question: How much confidence do your agencies have in being able to utilize this high energy upper stage in the near future on the Shuttle? What impact would disqualification of the Shuttle/Centaur system have on planned NASA and DOD missions?

Answer: The Shuttle/Centaur is a derivative of the highly successful Atlas Centaur. The Shuttle/Centaur design changes from the Atlas Centaur vehicle have been largely driven by safety requirements which are imposed upon all man-rated vehicles. The Shuttle/Centaur vehicle design is undergoing rigorous safety analysis and vehicle testing to assure safety. Recently completed tanking tests of the Shuttle/Centaur vehicle system at the launch complex have demonstrated the system's functional capability and integrity. The leak rate measured in these tests at 110% flight pressure level indicated the total leakage detected was well within Shuttle safety specifications.

It should be noted that each Centaur flight system is subjected to a series of stringent tests, leading up to Orbiter mating and launch.

We are proceeding to verify the safety of the Centaur as an upper stage in the STS. We are reviewing the Centaur and its impact on the Shuttle, and intend to make any necessary modifications for the safety of the system.

At present, three planetary missions are planned to use the Shuttle/Centaur; these are the Galileo, Ulysses and Magellan. Discontinuing plans for use of the Shuttle/Centaur would impact these three missions. These missions could be flown on the CELV (Titan 34D/7/Centaur G Prime); however, the Galileo would not be on a direct trajectory and arrival time to Jupiter would be delayed 2 additional years after launch. The CELV could launch Ulysses on a direct trajectory. Both Galileo and Ulysses would require a kick stage; this would necessitate a redesign to accommodate the kick stage into the spacecraft-launch vehicle stack. Magellan could be launched on a direct trajectory to Venus with the CELV.

An additional impact to these planetary missions is that the CELV launch capability is not presently planned to be available until 1988.

Although NASA procures the Centaur vehicles for DOD missions in the Shuttle, we recommend that the DOD impact, due to a disqualification of the Shuttle/Centaur, system be discussed with that agency.

STS Program Resumption

Question: For planning purposes, both NASA and DOD are assumming resumption of Orbiter flights in February of next year--with nine flights in the first 12 months of operations.

How confident are you in this baseline assumption and what alternative contingency plans are your agencies working on?

Answer: NASA will plan to meet a flight rate in the first year of operations that is determined to be safe based on studies that are currently being conducted. The rate of nine flights may or may not be acceptable based on the results of those studies. NASA plans to run the STS such that it is safe and dependable, and assures mission success. Six to seven flights are currently planned in the first twelve months of operation. Flight safety and conservatism, however, need not prevent a robust Shuttle launch schedule, to which we intend to return. We are currently planning to begin Shuttle operations in the summer of next year.

Initial Cost Estimates

Preliminary costs estimates of a replacement Orbiter and other accident recovery costs, total $3 billion for NASA. We understand that DOD estimated that its cost in terms of procuring additional ELV's may total $2.5 billion.

Question: While such estimates are preliminary and, of course, are not yet official budget requests of the Administration, can you give us a general idea of what is reflected in these estimates?

Answer: The preliminary funding estimates for a replacement Orbiter and other accident-related requirements, which require additional funding to the agency, are as follows:

- Corrective actions relating to the Solid Rocket Boosters and potentially to other elements of the Shuttle; depending on the specific actions required the additional funding needed--is estimated at $350 to $500 million
- A replacement Orbiter, including main engines and equipment lost with Challenger, such as, replacement suits and an RMS, started in 1986 and delivered in 36 to 42 months--is estimated at $1.9 to 2.0 billion. If the start were delayed, the estimated cost would be $2.2 to $2.4 billion
- IUS airborne support equipment lost with Challenger is estimated at--$36 million
- Replacement of Structural Spares to provide spares to the operational fleet and/or the capability to support a decision to build an additional Orbiter is estimated at--$450 million

A significant level of other accident related increases are planned to be absorbed in the budget. The primary areas of increase include failure investigations, and salvage operations.

Second Source

Admiral Truly, the second sourcing of SRM has been an issue for some time and NASA clearly stated its intent and expectations in developing a second source before the Challenger incident.

Question: Other than the reduced flight rate of the Shuttle system for the near and mid-term future, and the economic impacts of the Challenger accident, has NASA changed its position with respect to this issue.

Answer: NASA announced on December 26, 1985, that it would be in the national interest to proceed with a second source activity with the following specific constraints and conditions:

-- Because of budget constraints, no up front funds for qualification can be provided.

-- Upon successful qualification, NASA will buy 20 flight sets and provide the contractor an opportunity to compete for some split in the balance of SRM requirements. The decision to proceed with a second source qualification, and the procurement of these 20 flight sets, is predicated on NASA's budget availability.

-- NASA cannot provide a firm guarantee for recovery of any costs incurred for qualification.

Currently, we are preparing responses to questions submitted by the four contractors, Aerojet Strategic Propulsion Co., Atlantic Research Corp., Hercules, Inc., and United Technologies, Chemical Systems Division. NASA plans to proceed with an Request for Proposal (RFP) providing a positive response is received from at least one contractor after reviewing NASA's answers to their questions.

QUESTIONS SUBMITTED BY SENATOR LEAHY

Assured Access to Space

Question: According to materials prepared by the Air Force, if there is an 18-month delay before the Shuttle is ready to fly, there will be only about 20 Shuttle flights between now and 1988.

This is less than one-half of the flights that NASA has expected to fly during this period.

Using such an assumption the Congressional Budget Office has estimated that those 20 flights will be broken down as follows:

15-- Department of Defense

2-- Planetary launches

3-- Commercial launches

Do you believe that this estimate is substantially correct?

Answer: No. Any estimate under the current set of conditions is subject to change as we continue to assess changing requirements and options.

Currently, for the sixteen flights projected through the end of 1988, the payload assignments are distributed as follows:

	Dedicated	Shared	Total
NASA	5	0.52	5.52
DOD	6	1.33	7.33
Foreign and Commercial	0	3.15	3.15
TOTAL	11	5.0	16.0

There are four Shuttle flights planned to be initiated in July 1987 and 12 in 1988.

There is no SDI payload scheduled in CY 1987, and only one is scheduled in CY 1988.

Question: Does it disturb you that there will be only three flights available for "foreign, commercial and other NASA" launches?

Answer: We are disturbed by the impact the STS 51-L tragedy has had on all who use the Shuttle. We have attempted to distribute the impact as fairly as possible, consistent with the priorities established by the Administration. This puts national security first, but retains strong emphasis on NASA's major science programs, with special emphasis on the planetary missions which characteristically show intervals of more than a year between launch opportunities.

The limited number of flight opportunities for foreign, commercial, and other NASA payloads has at least two adverse effects. One, affecting the customer organizations directly, is either the delay in achieving their objectives and the availability of services to their customers or, when it is possible, the increased cost resulting from the use of a more expensive launch mode. The second is the impact on NASA's budget which results from the marginal cost associated with the flight. Because the difference has to be made up from NASA's appropriated funds, this puts increased budget pressure on NASA's programs for space exploration, science, and applications.

Question: According to testimony by General Abrahamson in public session before the House Science and Technology Committee, the Star Wars program plans to utilize "one equivalent Shuttle flight per year under the basic research category for the fiscal years 1987 through 1991."

Would it, therefore, be safe to assume that of the 15 or so DOD payloads between now and 1988, two or more will be Star Wars payloads?

Answer: Currently, there is only one SDI payload scheduled in calendar year 1988.

Question: Thus, if we delayed those Star Wars payloads, would not the amount of available Shuttle space for commercial, foreign, and other NASA payloads by a substantial percentage in the 1986-1988 period?. Why not put off these experiments and make more flights available for science and commercial uses?

Answer: Currently, there is only one SDI payload scheduled in calendar year 1988. In the case of these early SDI experiment flights we have, in fact, balanced the rescheduling with NASA's major science payloads, and with the foreign and commercial payloads as well. For example, in both the 12-month and the 18-month stand-down working options, there are three major science payloads; GALILEO, ULYSSES and the Hubble Space Telescope scheduled ahead of the first SDI flight. Also, there are shared NASA payloads and a number of commercial payloads scheduled before the SDI flight.

Question: Was the experiment last June, in which a laser was bounced off a mirror in the Shuttle, a vital experiment?

Answer: We understand that it was an important experiment, and that it afforded SDI with an efficient and effective means of conducting an otherwise complex experiment.

Question: Does NASA examine each of these DOD payloads and make an independent determination of their worth to make sure that they are actually vital to our national security?

Answer: NASA, in conjunction with the DOD, continually reassesses the relative priorities with critical National Security payloads having the highest priority. However, NASA does not independently assess national security requirements.

Question: I understand that NASA and DOD are still engaged in a process of determining what the manifest will be. In answering the following two questions, if the new policy is not decided when these questions are answered please describe a reasonable set of options. For example, the Air Force's materials describe the effects of the Shuttle being down for 6, 12 or 18 months.

Answer: We understand that DOD is planning about four dedicated SDI Shuttle flights through 1991. SDI also is planning two flights on the Delta ELV.

Question: How many SDI payloads do you expect will need to be flown between now and the end of 1991. Please indicate how many will be flown on the Shuttle and how many may be flown on other launchers.

Answer: We understand that DOD is planning about four dedicated SDI Shuttle flights through 1991. SDI also is planning two flights on the Delta ELV.

Question: Please also indicate how many Shuttle bay equivalents of SDI payloads that NASA expects to fly between now and 1991?

For each of the above, please provide the total number of payloads or Shuttle bay equivalents, and a year-by-year breakdown of those flights.

Answer: We expect to launch four SDI payloads between now and the end of 1991 at the rate of one per calendar year; 1 in 1988; 1 in 1989; 1 in 1990 and, 1 in 1991.

Question: How many total DOD payloads do you expect will need to be flown between now and the end of 1991? Please indicate how many will be flown on the Shuttle and how many will be flown on other launchers.

Answer: We expect to launch 23 dedicated DOD payloads and 14 GPS payloads between now and the end of 1991. We expect the DOD to launch 2 to 4 payloads per fiscal year on CELV's.

Question: Please also indicate how many Shuttle bay equivalents of SDI payloads that NASA expects to fly between now and 1991.

Answer: Current planning calls for four SDI Shuttle bay equivalents to be Shuttle launched between now and the end of 1991.

Question: For each of the above, please provide the total number of payloads or Shuttle bay equivalents, and a year-by-year breakdown of those flights.

Answer: We understand that DOD is planning about 4 dedicated SDI Shuttle flights through 1991. SDI also is planning 2 flights on the Delta ELV. We expect to launch four SDI payloads between now and the end of 1991 at the rate of one per calendar year; 1 in 1988; 1 in 1989; 1 in 1990 and, 1 in 1991.

Question: How many total DOD payloads does NASA expect to fly between now and 1991?

Answer: Assuming an 18-month stand-down, NASA expects to fly 23 dedicated and 14 GPS payloads between now and the end of 1991.

QUESTIONS SUBMITTED BY SENATOR LAUTENBERG

Question: Admiral Truly, Undersecretary Aldridge seems to be saying that national security payloads are, with a few exceptions, going to crowd out virtually all NASA foreign and commercial payloads, once the Shuttle resumes operations. Do you agree?

I think it would be helpful if you would provide us with a quantitative idea of the dimensions of the problem.

Answer: Currently, for the sixteen flights projected through the end of 1988, the payload assignments are distributed as follows:

	Dedicated	Shared	Total
NASA	5	0.52	5.52
DOD	6	1.33	7.33
FOREIGN AND COMMERCIAL	0	3.15	3.15
TOTAL	11	5.0	16.0

Question: How many Shuttle bay equivalents, including ELV's, were planned by NASA and DOD for the 1986 to 1992 time-frame, prior to the Challenger accident?

Answer: Prior to the Challenger accident, NASA and DOD had planned to launch 145 Shuttle flights between 1986 and 1992, in addition to 30 Shuttle bay equivalents on ELV's, for a total of 175 Shuttle bay equivalents.

Question: Could you tell us how many were national security, how many planetary missions, NOAA missions, foreign payloads, and commercial payloads?

Answer: Of the 145 Shuttle flights planned between 1986 and 1992, about 58 flights or 40 percent were projected to be DOD missions, 5 flights or 3 percent were planetary missions, 2 1/2 flights or about 2 percent were NOAA and about 25 1/2 flights or 18 percent were foreign and/or commercial payloads. Of the ELV's, 28 were national security, none were planetary, 2 were NOAA and none were foreign and/or commercial.

Question: How many Shuttle bay equivalents, including ELV's do NASA and DOD now project for 1986-1992 time-frame? Have our needs changed?

Answer: Our basic needs have not changed. Our current projections, assuming a 12-month stand-down and a replacement Orbiter, call for 105 Shuttle flights between now and 1992. The Shuttle bay equivalents for ELV's in that timeframe are 30, leading to a total of 135 Shuttle bay equivalents.

Question: Mr. Lee, what are NASA's plans for Delta rocket launches? What are its priorities? Is the West Star VI-S satellite scheduled for launch? What is the 1986-1987 schedule for Delta launches?

Answer: NASA has been reviewing and considering various options regarding the future application of the Delta and other Expendable Launch Vehicles. The current status of the Delta launch vehicle consists of four mission launches planned during 1986 and 1987. Two missions are for the Department of Commerce, National Oceanic and Atmospheric Administration's Weather Satellite Program, and two are for the Department of Defense's Strategic Defense Initiative (SDI) Office. After these launches, our inventory of completed Delta vehicles will be exhausted and the program is scheduled to be phased out by NASA at the end of 1987.

Consideration to re-open the production of Delta hardware and launch of Delta as a commercial venture continues to be explored by NASA and Trans Space Carriers, Incorporated (TCI). NASA has entered into a preliminary agreement with TCI which grants TCI the sole rights to market the Delta vehicle. This agreement was established in May 1984. To date, TCI has not been able to market any Delta launches.

In addition to the planned scheduled launches of the four Delta vehicles referred to above, residual flight development of partially completed Delta's (182-184), and residual long lead materials, are in inventory. Under the terms of December, 1985 Memorandum of Understanding (MOU) between SDIO and NASA, these are available for use by SDIO. The current estimate is that additional Delta's could be ready in two years time, if the partially completed Delta's were used in production.

NASA is working with Western Union (Westar VI-S) and other commercial satellite customers in assessing alternatives to support their launch requirements. Although the accident will affect the ability to support every customer, NASA intends to do what it can to lessen the impact.

Question: Admiral Truly, last year NASA worked pretty hard to persuade NOAA to plan Shuttle launches of its weather satellites. In the past, they went up on expendable launch vehicles. In retrospect, was that a wise decision?

Is it reversible? If need be, could the NOAA satellites go back on Titan II's, as had been contemplated?

Answer: I believe the NASA/NOAA agreement to use the Shuttle for the NOAA meteorological satellites made sense in terms of maintaining an economical flight rate for the Shuttle at the Vandenberg launch site, and we are showing these launches in our projected flight manifests. I am not aware of any technical considerations that would rule out reverting to an ELV. I believe that this consideration should be part of the national determination of what the overall Shuttle/ELV mix should be.

Question: During the hearing on March 25, Deputy Administrator for NOAA, Curtis Mack, alluded to an "Omnistar" platform, that might combine both remote sensing and meteorological functions. Has NOAA been in contact with NASA about that? What impact would any change have on NASA launches?

Answer: We understand that the RCA "Omnistar" concept is the baseline configuration for this year's definition effort for the Landsat 6 Satellite, and that there is some consideration being given to the possibility of adding a meteorological capability to it. If such a combination if feasible, it could reduce the number of launches required to support the NOAA programs.

Question: What priority do you give to NOAA launches?

Answer: NASA regards the NOAA satellite programs, particularly, the meteorological programs, as essential national services whose continuity is of vital importance. Our general policy is to accommodate all payload schedule requirements as closely as possible on a first-come, first-served basis. Where there are conflicts, we work with the affected parties toward a mutually acceptable disposition, with an underlying priority order as follows:

Critical national security payloads

Scientific payloads with specific launch windows

Other U.S. Government, foreign, and commercial payloads

The normal NOAA launches, thus, come directly after the time-critical major NASA payloads. Our agreement with NOAA also provides for three-month call-up launches to replace inoperative NOAA satellites.

Question: Admiral Truly, there seems to be movement in the administration toward proposing both a fourth Orbiter and additional ELV's.

During the hearing on March 25, we discussed the issue of manned versus unmanned space--this is not a new question. I agree that men and women should be in space. The Challenger accident, does, however, make us reconsider the balance. And, the question applies to the problem of what we do not--the Shuttle is a manned vehicle.

How many of the launches that will be back-logged need a manned vehicle?

How many can go on an ELV?

Answer: It is not possible to determine at this time, with accuracy, the number of backlogged launches that must be manned or that could be launched by an ELV. However, thru FY 92 approximately 100 out of 230 payloads (43 percent) could be flown on ELVs, with some additional costs. This includes all foreign and commercial communication satellites, DOD GPS and other DOD payloads, and other U. S. Government (NOAA, Landsat, GOES, Lageos, etc.) This includes about 7 percent of the NASA payloads, 88 percent of the commercial/reimbursable payloads, and 71 percent of the DOD shared and dedicated payloads.

Thus, approximately 130 out of 230 Shuttle payloads (57 percent) of the payloads are Shuttle dependent or would be too expensive to move to ELV's.

Question: Do we need a fourth Orbiter? Would three be enough to meet the demand for manned missions?

Answer: A replacement Orbiter would help to support critical national security needs, Space Station installation and operations, and NASA science missions, particulary those with critical launch windows. If there were only three Orbiters, and an Orbiter had to be removed from the flight schedule, we would not be able to meet currently defined requirements.

DEPARTMENT OF THE AIR FORCE RESPONSE TO QUESTIONS

QUESTIONS SUBMITTED BY SENATOR GARN

SHUTTLE/CENTAUR SYSTEM

QUESTION: NASA is engaged in a comprehensive review of the entire Shuttle system including detailed re-examination of all critical items. Concern has been expressed over the planned use of the Centaur G upper stage since it uses liquid hydrogen and oxygen as a propellent and, therefore, is more technologically complex and demanding than other storable upper-stages.

How much confidence do your agencies have in being able to utilize this high energy upper stage in the near future on the Shuttle?

What impact would disqualification of the Shuttle/Centaur system have on planned NASA and DOD missions?

ANSWER: The Centaur development is being managed by NASA. Based on the information received from NASA to date, the Air Force is still planning to utilize the Centaur upper stage for Shuttle missions. NASA is closely monitoring the Centaur development, and we will continue to work with them as the development progresses. The DOD/NASA Space launch recovery plan will implement dual Shuttle/CELV compatibility for DOD payloads. As a general rule, with dual compatibility, disqualificaton of the "Shuttle/Centaur system" would have minimal impact to DOD. The first planned use of the "Shuttle/Centaur system" in the recovery plan is for a NASA planetary mission in 1987. The impact of a disqualification on this mission would have to be determined by NASA.

STS PROGRAM RESUMPTION

QUESTION: For planning purposes, both NASA and DOD are assuming resumption of orbiter flights in February of next year -- with nine flights in the first 12 months of operations.

How confident are you in this baseline assumption and what alternative contingency plans are your agencies working on?

ANSWER: The DOD is concerned that the Shuttle downtime may exceed 12 months and the flight rate, once the Shuttle starts flying, may be constrained for safety reasons. DOD planning assumptions have been based on a 12 month downtime. If the Shuttle is down longer than 12 months, DOD mission impact will dictate use of more of the available Shuttle capacity. Also, the possibility of acquiring even more expendable launch vehicles (ELVs) will have to be examined. However, the near term DOD recovery plan will not be altered by a longer standdown. DOD payloads must be modified for dual Shuttle/ELV compatibility where practical and ELV production/modifications must be started immediately. Plans for a longer than 12 month standdown are in work, and will be finalized after the Rogers' Commission recommendations are made.

INITIAL COST ESTIMATES

QUESTION: As I indicated in my opening remarks, both our Subcommittees are concerned with the impact of the Challenger tragedy on our ability to meet National Launch requirements.

We all agree with Admiral Truly's view that our first priority is to restore safe and efficient Shuttle operations. We also agree that to recover from the standdown of the orbiter fleet, we will need additional expendable launch vehicles (ELVs). It also appears imperative that a replacement orbiter be procured as soon as possible.

Within these parameters, however, exists a panoply of questions and concerns over cost, program policy, technical soundness, and program impact.

Preliminary costs estimates of a replacement orbiter and other accident recovery costs total $3 billion for NASA. We understand that DOD estimated that its cost in terms of procuring additional ELVs may total $2.5 billion.

While such estimates are preliminary and, of course, are not yet official budget requests of the Administration, can you give us a general idea of what is reflected in these estimates?

ANSWER: The DOD plan for recovery of space launch capability includes spacecraft/expendable launch vehicle (ELV) modifications for dual compatibility, 12 medium ELVs, 13 additional CELVs, a CELV pad at Vandenberg AFB and CELV processing enhancements. For planning purposes, the additional requirements are $562M in FY 86, $801M in FY 87 and total $4.3B for FY 86 through FY 92. There will be orbiter flight charge offsets as a result of flying on ELVs rather than the Shuttle, but the amount and timing of those offsets are subject to negotiation between DOD and NASA.

QUESTIONS SUBMITTED BY SENATOR STEVENS

PRODUCTION OF A MID-RANGE BOOSTER

QUESTION: The Air Force informs us that virtually every space booster in the existing inventory has an assigned payload. These boosters cannot be used to take some of the DOD Shuttle backlog. The expendable launch vehicle production base in the U.S. is at a low ebb. The Atlas and Scout production lines are closing, and the final Titan 34D booster is in assembly, with production terminated. The Delta launch vehicle team is still together, but no further procurements are on contract. The new CELV (Titan 34D7)--a derivative of the Titan 34D-- will not be delivered and launched until 1998. Would the requirement for production of a mid-range booster recede if a new Shuttle Orbiter becomes available in the early 1990s?

ANSWER: All expendable launch vehicles awaiting launch or currently in production have assigned payloads. Although the Complementary ELV, approved by Congress last year as a means to assure access to space, will begin deliveries in 1988, all vehicles have designated satellites. Employment of ELVs to reduce the national launch backlog resulting from the Shuttle accident will require new booster production. Even with a new Orbiter in the early 1990s, the STS standdown, combined with rebuilding flight rates, creates a significant launch backlog. Reducing foreign and commercial payloads will not diminish the excess demand. By procuring additional ELVs, mission deficit growth can be brought under control, but more importantly a robust, mixed fleet space launch capability can be achieved for assured access to space. DOD's recommended space launch recovery plan also includes transferring certain DOD satellites from the Shuttle to a medium launch capacity ELV. Considering military space launch requirements and the critical need for access to space, a medium launch vehicle is not dependent on orbiter procurement, but is justified on its own merits.

RESUME PRODUCTION OF ATLAS OR DELTA BOOSTERS

QUESTION: What specific measures would have to be taken to resume production of Atlas or Delta boosters and what are the costs?

ANSWER: Since each of these booster lines is engaged in some form of activity, no significant production reactivation measures and costs are projected. Launch teams are still in place, so there is a minimal impact to the basic production, test and launch organizations of each contractor. Our analysis shows that modifications to both of these boosters, as well as some Titan configurations, would be necessary to launch medium class satellites.

TITAN 34D PROGRAM

QUESTION: Would you consider a restart of the Titan 34D program and would that impact the Titan 34D7 program?

ANSWER: Additional expendable launch vehicles are part of the recommended plan for recovery of space launch capability as a result of the Challenger accident. One recommendation is a medium capability expendable launch vehicle. Several viable candidates are being proposed by industry, and the Titan family, including the Titan 34D is included. Procurement of additional Titans may be beneficial to the Titan 34D7 Complementary ELV program through economy of scale. However, production capacity could be a problem when the CELV and Titan II modification programs are considered simultaneously with additional Titan 34D vehicles.

EXPENDABLE LAUNCH VEHICLES (ELVs)

QUESTION: Air Force plans for 2 classes of ELVs: a large payload (10,000 pounds) Titan 34D7 and a medium payload booster yet to be determined.

Congress has approved 10 Titan 34D7s; a reprogramming is enroute to realign FY 1986 funds for multiyear procurement.

Total CELV (Titan 34D7) multiyear procurement cost is now $2.9 billion, or $800 million more than projected last year. The difference is due to overhead and management reserves. (We have the break-out.)

The Air Force is considering the following additional ELV acquisition program in response to the Challenger Accident:

+11 to 12 Titan 34D7s
+20 medium boosters
ELV launch capability from Vandenberg.

ELVs will be produced at the maximum yearly rate (5 for the Titan 34D7 and 4 for the medium booster: properly managed, this will reduce unit costs (e.g., Titan 34D7 will come down from $80 million to $67 million, and save nearly $300 milion).

Secretary Aldridge, we're told that a $560 million supplemental for ELV production is in the works. When will it be submitted to Congress? Can all of it be put on contract in FY 1986?

ANSWER: Additional ELV capacity is part of the recommended plan for recovery of space launch capability. Although the DOD recommendations have been made for an enhanced mixed fleet, final approval for the overall plan and the supplemental budget request rests with the President. This issue is now being worked through the Senior Interagency Group on Space. The supplemental involves about 12 DOD programs, not only space boosters. Tasks such as storage of spacecraft now ready for Shuttle launch are included. The supplemental should be submitted to Congress in the next few weeks. Since we currently have existing contracts for launch vehicle and satellite procurement, these resources can be placed on contract this year.

VANDENBERG SHUTTLE FACILITY

QUESTION: Space Shuttle Operations is the fastest growing component of the Air Force Operations and Maintenance budget. 1986 appropriation (pre-Gramm-Rudman) of $634 million increasing to $904 million in the 1987 President's budget -- 38% real growth.

Vandenberg AFB Shuttle operations alone is $250 million in 1986 and $355 million in 1987.

The Vandenberg Shuttle facility was deemed operational on October 1, 1985. Over 3,000 contractor personnel are on the payroll with no launches proceeding.

The Vandenberg Shuttle facility became operational last October and has over 3,000 contractor personnel on board for Shuttle operations. Since no flights are planned this fiscal year, what are all these employees doing? Has the Air Force taken any efforts to reduce the workforce?

ANSWER: In FY 86, the Vandenberg Launch and Landing Site (VLS) successfully completed the NASA Level I Design Certification Review and proceeded into preparations for the first launch. These preparations include several special tests unique to the first launch. As development work has been completed, the contractor work force has been reduced from a level of over 4000 in FY 85 to under 3000 in mid FY 86. When Full Operational Capability is achieved in FY 87, the work force will level off at 2100-2500 contractor personnel. This represents the level of personnel needed for the baseline requirement of up to four launches per year and must be maintained if this launch capability is desired at VLS. Since VLS is located in a rural area and the technical skills required in a launch team are not widely available, a major reduction in the workforce is not achievable unless no launches were planned for more than three years.

COST RELATED TO VANDENBERG OPERATIONS

QUESTION: Shuttle operations represent one of the major increases in the President's 1987 budget; increasing from $634 million to $904 million (38% real growth). Aren't these costs primarily related to Vandenberg operations?

ANSWER: No. The cost increase is due to increased Orbiter Flight Charge reimbursements from $87M in FY 86 to $268M in FY 87 for five operational missions.

FLIGHT CHARGE TO NASA

QUESTION: Air Force has been required to pay the Orbiter flight charge to NASA one year in advance of a Shuttle launch. Since no flights are planned this year, does this mean that FY 1987 payments aren't necessary?

ANSWER: No. According to the NASA/AF Memorandum of Agreement on Reimbursement of Launch and Associated Services for Uses of the Space Shuttle, 1 Feb 83, any charges for unused services shall be credited to DOD needs in the fourth year of the rolling commitment period. The two DOD flights not flown in FY 86 will result in two flight credits in FY 89.

DUAL COMPATIBLE SATELLITE LAUNCHES

QUESTION: The Air Force intends to make most of its key satellites CELV-compatible, meaning that they will be capable of being launched from the Titan 34D7 as well as the Space Shuttle in the future.

Some of the key satellites to be modified for dual compatibility include: Milstar, DSP, GPS, and DSCS.

The Air Force is also considering off-loading GPS satellites from the Shuttle flight manifest. With GPS satellites offloaded from the Shuttle, more Shuttle payloads could be freed for NASA's scientific missions and commercial purposes.

What portion of your FY 1986 supplemental request will pertain to dual compatible satellite launches? What satellites are being considered for modification for CELV compatibility? What are the costs associated with making satellites dual compatible?

ANSWER: The DSP satellite and booster modifications for dual compatibility were already planned and programmed. DSCS is being considered for modification for CELV compatibility. Milstar is considering accelerating the dual compatability from its fourth satellite to its first satellite. GPS is being considered for modification for launch by a proposed medium launch capability booster.

The cost of making satellites dual compatible varies with design complexity and maturity. The portion of the proposed DOD FY 86 supplemental for accelerating Milstar and starting the GPS and DSCS dual compatibility efforts is approximately $59 million. Preliminary estimates of the FY 86 portion of the cost for dual compatibility are $19M for GPS, $8M for DSCS and $32M for Milstar. This includes funds for unique satellite and booster design and modification.

Questions Submitted by Senator Leahy

NUMBER OF SHUTTLE FLIGHTS

QUESTION: According to materials prepared by the Air Force, if there is an 18 month delay before the Shuttle is ready to fly, there will be only about 20 Shuttle flights between now and 1988.

This is less than one-half of the flights that NASA had expected to fly during this period.

Using such an assumption, the Congressional Budget Office has estimated that those 20 flights will be broken down as follows:

15 -- Department of Defense
2 -- Planetary launches
3 -- Commercial launches

Do you believe that this estimate is substantially correct?

ANSWER: There is no joint agreement between NASA and DOD on a 18 month delay manifest. However, preliminary estimates are as follows:

	JUL 87 - DEC 88 Shuttle Bay Equivalent Flights
Department of Defense	7.3
NASA	2
NASA Planetary	3
Commercial/Foreign	3.7
Total	16

AVAILABLE FLIGHTS FOR OTHERS

QUESTION: Does it disturb you that there will be only three flights available for "foreign, commercial and other NASA" launches?

ANSWER: DOD made a commitment to use the Space Shuttle as our primary means of access to space. A large backlog of high priority national security payloads results from the loss of the Challenger, resultant Shuttle standdown and unavailability of new ELVs until late 1988.

Although there is no joint agreement between NASA and DOD on a 18 month delay manifest, preliminary estimates show foreign, commercial and NASA (other than planetary) launches at 5.7 of 16 total Shuttle bay equivalent flights (SBEF) between Jul 87 and Dec 88. Adding the 5.7 SBEFs to the 3 NASA planetary launches leaves DOD with less than half the total SBEFs.

While DOD would launch mostly dedicated flights, most foreign, commercial and other NASA payloads would be able to fly as cargo mixing partners to the Global Positioning System (GPS) satellites on the Space Shuttle Columbia. Columbia is too heavy to carry most dedicated DOD payloads and GPS launches on Columbia are limited by other constraints. Hence, the use of Columbia for other than DOD flights has little or no impact on the DOD mission requirements.

STAR WARS PAYLOADS

QUESTION: According to testimony by General Abrahamson in public session before the House Science and Technology Committee, the Star Wars program plans to utilize "one equivalent Shuttle flight per year under the basic research category for the Fiscal Years 1987 through 1991".

Would it therefore be safe to assume that of the 15 or so DOD payloads between now and 1988, two or more will be Star Wars payloads?

ANSWER: Only one dedicated DOD SDI flight is planned prior to the end of 1988. However, a few small experiments and SDI-related payloads are planned for the same period.

DELAY OF STAR WARS PAYLOADS

QUESTION: Thus, if we delayed those Star Wars payloads, would not the amount of available Shuttle space for commercial, foreign, and other NASA payloads increase by a substantial percentage in the 1986-1988 period. Why not put off these experiments and make more flights available for science and commercial uses?

ANSWER: Since there are relatively few SDI and SDI-related flights in the 1987-1988 period, delaying them would not provide substantially greater science and commercial opportunities. In addition, the mission impact of delaying the SDI and/or SDI-related flights would be substantial.

LASER EXPERIMENT

QUESTION: Was the experiment last June in which a laser was bounced off a mirror in the shuttle a vital experiment?

ANSWER: Yes. The laser tracking test was a critical, low cost, risk-reduction experiment for the sounding rocket experiments which were subsequently conducted at Maui, Hawaii last fall. The shuttle test provided valuable experience that was essential to the successful acquisition and tracking of the sounding rockets which carried the same mirror (a retroreflector) as the shuttle.

NASA EXAMINATION OF PAYLOADS

QUESTION: Does NASA examine each of these DOD payloads and make an independent determination of their worth to make sure that they are actually vital to our national security?

ANSWER: NASA does not determine whether a payload is vital to our national security. However, there has been and currently is close cooperation between DOD and NASA in developing the Shuttle Mission Model to ensure the most efficient use of this national asset. To date, DOD has never had to exercise its right to pre-empt based on national security priority.

SDI PAYLOADS

QUESTION: I understand that NASA and DOD are still engaged in a process of determining what the manifest will be. In answering the following two questions, if the new policy is not decided when these questions are answered please describe a reasonable set of options. For example, the Air Force's materials describe the effects of the Shuttle being down for 6, 12, or 18 months.

How many SDI payloads do you expect will need to be flown between now and the end of 1991. Please indicate how many will be flown on the Shuttle and how many may be flown on other launchers.

Please also indicate how many Shuttle bay equivalents of SDI payloads that NASA expects to fly between now and 1991.

For each of the above, please provide the total number of payloads or Shuttle bay equivalents and a year by year breakdown of those flights.

ANSWER: Using either a 12 or 18 month Shuttle standdown assumption, the total SDI Shuttle bay equivalent (SBE) flights planned through 1991 is 4.66. Two Delta expendable boosters will launch SDI payloads (1/3 SBEs each) in 1986-7. Four dedicated SDI Shuttle flights are planned in 1988-92; one each year. There may also be some SDI related payloads and small SDI experiments on the Shuttle, but they are not firm yet.

DOD PAYLOAD

QUESTION: How many DOD payloads do you expect will need to be flown between now and the end of 1991? Please indicate how many will be flown on the Shuttle and how many may be flown on other launchers.

Please also indicate how many Shuttle bay equivalents of SDI payloads that NASA expects to fly between now and 1991.

For each of the above, please provide the total number of payloads or Shuttle bay equivalents and a year by year breakdown of those flights.

ANSWER: Assuming a 12 month Shuttle standdown and approval of additional expendable launch vehicles (ELVs) (13 Complementary ELVs and 12 medium ELVs), the total DOD and SDI Shuttle bay equivalent (SBE) flights planned through 1991 is 30.63. Prior to the April 18th Titan 34D accident, the planned ELV flights in SBEs through 1991 (including launches of additional ELVs) is (deleted). The effect of the Titan accident on the planned ELV flights will depend upon the results of the accident investigation. A summary table, broken out by calendar year, follows:

	CY86	87	88	89	90	91	Total
DOD Shuttle SBE Flights*	0	3.66	7.11	8.45	3.71	7.7	30.63
SDI Shuttle SBE Flights**	0	0	1	1	1	1	4
DOD ELV Flights in SBEs ***							
Annual DOD SBE Flights							

* Includes SDI dedicated flights but not SDI related payloads and small SDI Shuttle experiments.

** SDI dedicated flights. Does not include SDI related payloads and small SDI Shuttle experiments.

*** Schedule of near term launches affected by Titan 34D accident. Assumes additional ELVs approved.

TOTAL DOD PAYLOAD

QUESTION: How many total DOD payloads does NASA expect to fly between now and 1991?

ANSWER: Assuming a 12 month standdown, NASA plans on flying approximately 33 DOD Shuttle bay equivalent payloads through 1991.

QUESTION SUBMITTED BY SENATOR LAUTENBERG

COMBINING SATELLITE MISSIONS

QUESTION: You have discussed a large backlog of military payloads that with the exercise of bumping rights can crowd out a lot of others on the Shuttle.

Some of those military missions, I presume, involve the launch of defense weather satellites...and communications satellites...is that right?

In the interest of conserving and allocating scarce launch opportunities, is there any way of combining some of these? Let's say, combining a civil weather satellite and a defense weather satellite? Why can't you fly your instruments on the same satellite as NOAA flies its instruments?

ANSWER: The Defense Meteorological Satellite Program (DMSP) will not launch on the Shuttle through the late 1990's. DMSP Block 5D satellites will be launched more efficiently and economically on Atlas E launch vehicles through FY 1990, transitioning to Titan II thereafter.

It is not possible to combine current DOD and NOAA payloads on the same satellite. While the systems are similar, they have different primary missions and different primary sensors. Cloud imagery is the primary DOD need, while vertical temperature and moisture soundings are the primary NOAA need. In addition, NOAA flies other payloads such as search and rescue and data collection systems which DOD does not. Neither satellite has sufficient payload capacity to carry the combined DOD and NOAA payloads. In fact, a recent DOD study made at OMB request showed that DMSP could not fly the NOAA search and rescue payload without removing DOD payloads. Flying DOD payloads on the NOAA spacecraft would also be precluded by DOD survivability and data and command encryption requirements.

CONCLUSION OF HEARINGS

Senator GARN. That concludes the hearings. The subcommittees will stand in recess and reconvene at the call of the Chair.

[Whereupon, at 3:32 p.m., Wednesday, March 26, the hearings were concluded and the subcommittees were recessed to reconvene at the call of the Chair.]

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